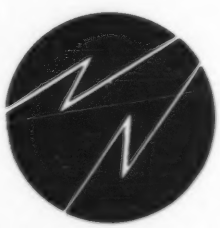
The Evolution of the Manufacturing Component in the Ontario Metal Mining Industry

Alan G. Green
M. Ann Green
Gerhard Anders

Working Paper No. 46



Centre for Resource Studies

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Alan G. Green
M. Ann Green
Queen's University

In collaboration with
Dr. Gerhard Anders
Chief Research Analyst
Mines and Minerals Division
Ministry of Northern Development and Mines

Centre for Resource Studies
Queen's University
Kingston, Ontario

April 1991

91-06762/

Canadian Cataloguing in Publication Data

Green, Alan G., 1932-

The evolution of the manufacturing component

(Working paper; 46)
ISBN 0-88757-104-2

1. Metal trade-Ontario-History. 2. Ontario-Manufactures-History. 3. Metallurgy-Ontario-History. 4. Ontario. The Mining Act. I. Green, M. Ann. II. Queen's University (Kingston, Ontario). Centre for Resource Studies. III. Title. IV. Series: Working paper (Queen's University (Kingston, Ontario). Centre for Resource Studies); 46)

HD9506.C23055 1991 338.4'5671'0971 C91-090330-1

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Foreword

This study was commissioned and funded by the Ontario Ministry of Northern Development and Mines (OMNDM). The Ontario government has long been concerned with designing policy instruments to promote increased economic activity based on the province's natural resources. In 1917, the province introduced Section 104, an amendment to the Ontario Mining Act, which requires that all ores or minerals mined in Ontario be processed in Canada before export. (For constitutional reasons, Ontario legislation can require processing within Canada but not specifically within Ontario.) Exemptions from the requirement are given from time to time, under special circumstances.

This study looks at the evolution in the degree of processing of metallic minerals in Ontario, principally for nickel, copper, and zinc. Measures of the degree of processing include: the ratio of value added in smelting and refining in Ontario to value added in mining; the ratio of unit production costs in Ontario to LME metal prices; and the value of metals refined in Ontario as a percent of mine output. All three measures indicate an increase in the processing of metals in Ontario since 1917. Backward linkages of the smelting and refining sector, such as purchases of materials, supplies and energy, are also considered.

Readers should bear in mind that this study is not intended to be an analysis of the decision-making process leading to investment in processing facilities, or an investigation of the entire range of factors that enter into such decisions, such as fiscal policies and incentives, energy availability, technological considerations, monetary policy, tariffs, etc. The authors focus their analysis on Section 104, and its relation to the metallic mineral sector in the province. They find that, theoretically, restrictions on the export of unrefined material can be expected to lead to a reduction in mine production over what might be expected under free-market conditions. The rationale for Section 104 therefore has been and is to promote expanded activity in the processing and refining sectors. The authors conclude that Section 104 has been effective in accomplishing this goal for the Ontario government, especially in the first decade of its existence, when they attribute its success in large part to the "infant industry" situation at that time.

At the request of OMNDM, the study also includes a chapter on recent trade negotiations (FTA and GATT), since market access is essential to the successful operation of a processing industry that produces in excess of domestic requirements.

The CRS Working Paper Series is intended to provide information and analysis that will be of use in the decision-making process in the mineral sector, and to encourage further research and feedback from both academics and practitioners. The views expressed are those of the authors, and do not necessarily reflect the views of the Centre for Resource Studies or its sponsors, or of the Ministry of Northern Development and Mines.

Margot J. Wojciechowski
Executive Director
Centre for Resource Studies

Preface and Acknowledgements

This study was first proposed by the Ministry of Northern Development and Mines as part of its review of the Mining Act of Ontario and focuses in particular on the progress of further processing of Ontario metal mines from 1900 to date. This is the issue addressed by Section 104 of the present Act. While the work was still in its early phase the Ministry requested, as part of a joint study with the Ministry of Industry Trade and Technology (M.I.T.T.) that the authors include in their interviews with the mining companies, questions concerning the consequences for the mineral industry of the Uruguay Round of GATT negotiations.

The central theme of this study is an assessment of the role that Section 104 played in increasing the degree of domestic processing undertaken on the raw material mined in the province. This focus ties in closely with the GATT round of negotiations, since most of the mineral production of Ontario is exported, and the more highly processed goods encounter higher tariffs in foreign markets. To the extent that such foreign tariffs are effective, they conflict with the overall goal of the Ontario government of enhancing the income and employment effects of the mining industry on the province by encouraging more domestic processing.

The authors wish to thank Mr. Dennis Tieman, Assistant Deputy Minister of Northern Development and Mines at that time, for providing the encouragement and financial assistance which allowed this study to go forward. This work is part of the ongoing research on economic aspects of mineral policy carried on by the authors in conjunction with the Centre for Resource Studies at Queen's and generously supported by the Ministry.

During the course of this study, the authors interviewed a large number of people in the mining industry. Still others spent a great deal of time filling out the questionnaire. Their help was invaluable to the completion of this work. The authors would like to thank them for the generous amount of time and effort they expended.

Throughout the intensive research phase of this project the authors were aided by Dr. Gerhard Anders, Chief Research Analyst, Mines and Minerals Division, who initiated the study by developing the concept of measuring the degree of process advances and helped in preparing the statistical data base upon which this study was built. They are indebted to him for his support and guidance.

Systematic research on the economics of the mineral industry in Canada is in its infancy. Without the continued encouragement and support received for projects such as this one, it is doubtful that such work would be possible. The authors appreciate the backing they have been given to pursue research in this important area.

Alan Green
Ann Green
Queen's University

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1. Introduction

As part of its general review of the Mining Act of Ontario, the Ministry of Northern Development and Mines wished to review, in some detail, the implications of Section 104 of the Act. This section was added as an amendment to the Act in 1917. Its basic purpose was to ensure that metal and mineral products mined in the province would be refined before export. Such a requirement was meant to raise the value-added component of these natural products. In economic terms, the Section was to ensure that some of the gains accruing from processing past the extraction stage of these products would be retained for the citizens of the province, in particular for its northern residents.

Measuring changes in the scope of metal production over long periods of time is difficult. Several approaches were adopted in this study. First, a detailed industry-by-industry review was made of the timing and nature of changes in degree of processing introduced since the early decades of the century. Second, a study was made of the growth and impact of the smelting and refining industry over recent decades.

Finally, and probably most important, a long-term investigation was undertaken of the ratio of unit price to world metal price (hereafter metal price). Unit price is defined as total value of Ontario production of a particular metal in all its forms, divided by total quantity produced. As the scope of production changes (i.e. as more products with a higher value added are produced), *ceteris paribus*, this ratio should rise relative to the price of the standard specification metal. The study was carried out on a metal-by-metal basis.

In addition to this direct investigation, but related to Section 104, the authors were asked to investigate the impact of GATT negotiations on the Ontario metal mining sector. This sector has received little direct attention in these negotiations, at least compared to agriculture, manufacturing and, more recently, services. This investigation was carried out by interviewing specific metal producers.

Anticipating the results, the basic findings are

- that Section 104 met its original objective of promoting the creation of a viable metallic mineral processing sector;
- failure to accord proper attention to the minerals and mining sector in future negotiations (and Free Trade Agreement discussions) could seriously affect the development of this vital industry.

The study is organized as follows. Chapter 2 sets out the origin of Section 104 and explores, by metal, the introduction of processing activities for various metals. This is followed in Chapter 3 by the theoretical underpinning of Section 104. The growth of the smelting and refining industry is described in Chapter 4, and the implications of trends in the ratio of unit to metal prices are explained in Chapter 5. The results of the inquiry into GATT and Free Trade Agreement (hereafter FTA) discussions are considered in Chapter 6, since they are of relevance to the question of market access for refined metals. The study concludes with a summary of findings, and some recommendations that follow from the investigation of these topics.

2. The Evolution of the Domestic Processing Condition

Historical Background[1]

The Ontario Mining Act regulates exploration and mining activities carried out in the province. This act has a long history dating back to the late decades of the 19th century. With the passage of the Mines Act of 1906, the basic form of regulations was set. Many of these regulations still form the basis of the current rules governing the management of provincial mineral resources.

Our interest is with the 1917 amendment to the Mines Act which imposed certain minimum domestic processing requirements on mining land severed from the Crown after 1917. The motives for this amendment were straightforward: to induce refining activity in the province; to prevent Ontario nickel being used by the Germans during World War I; and to discourage operators from exporting unrefined material.

Attempts by the Government of Ontario to have nickel refined in Canada date back to the late 19th century. Shortly after nickel mining began in 1889, the Ontario government petitioned the British government and the Admiralty in 1891 to underwrite the cost of establishing a refinery in Ontario. The British authorities refused. The argument was that, by assisting in the development of refining capacity in Canada, the British would secure safe access to nickel – a valuable addition to steel that substantially enhanced the toughness of steel used in making armour plate for war ships.[2]

It is not entirely clear what the subsequent motives of the government were in attempting to have nickel ores refined in the province. Retaliation against a US duty on sawn wood imposed in 1897 is one idea. Another is the desire by the government to enhance value added in the export of natural resources regardless of other countries' actions.

Attempts to encourage refining of nickel in Canada date back to the time the mining of the ore began. A formal attempt to encourage domestic processing was made in 1897 by the Government of Canada by means of an export tax on nickel matte. This act was never proclaimed. In 1900 the Province of Ontario passed an act which required all metallic mineral producers to obtain a licence, renewable annually.[3] In addition, a fee was to be based on the quantities of ores or minerals raised during the preceding year. The producers objected to the federal government, and this act too was abandoned, even though the Province believed it was within its jurisdiction to impose such conditions. After this the Province ceased any formal attempts to regulate the export of raw material until World War I. Problems emerged during the early years of the war when the newly formed International Nickel Company – a merger of the Canadian Copper Company (which became the mining wing) with the Orford Nickel Company (the US refining wing) led to the rumoured export of nickel to Germany.

The Amendment of 1917, which is the principal focus of this study, came after these events, and after the introduction of low-cost power to the industry. Apparently, by this time it had become profitable to refine ores in Canada, as evidenced by the fact that the decision had been made to establish refineries at Port Colborne and at Sudbury. Since export taxes were not possible, the provincial government amended the Mines Act in a way which imposed a condition on all companies severing land after 1917. The Act was changed to read

> all ores or minerals raised or removed therefrom shall be treated and refined in Canada unless exempted by the Lieutenant Governor in Council[3]

---

1 This section draws heavily on material prepared by William Logan of the Ministry of Northern Development and Mines.

2 Ontario Mines and Minerals Policy and Legislation: *A Green Paper*, Ministry of Northern Development and Mines (Toronto, 1988), p. 28.

3 Royal Ontario Nickel Commission, 1917, "Report and Appendix" (Toronto, 1917), p. xxvi.

Violation of this amendment could mean that the lease, patent or other means by which the land was held could be voided by the Lieutenant Governor in Council. The Province was clearly serious in its goal that the "whole of the nickel output of Ontario should be refined within her borders". Whether an attempt to invalidate a patent would have withstood a court challenge was never tested.

The 1917 Amendment to the Mines Act under Subsection 3 allowed for exemptions from the rules governing what could be exported. A request for exemption is complicated, involving the presentation to the Minister of detailed reports on the appropriate technical and financial considerations.

Exemptions to the domestic processing requirement may be granted under two subsections. Under Subsection 2, the Minister may define at what stage of processing any metal or mineral is "suitable for direct use in the arts", e.g. doré gold bullion or nickel oxide powder. This is a permanent blanket determination valid for all material specified, regardless of the source. Under the third subsection, the Minister may exempt any mining lands for whatever technical or economic reasons he deems proper. This is a time-and-quantity-limited determination valid for material from specified claims.

Reasons for many such exemptions have changed over time in response to the growing complexity of mineral processing and changing market conditions. For example, as the Japanese market expanded in the 1970s, Canadian producers could gain access at low or zero rates of import duties only by writing contracts for semi-refined (matte) rather than refined nickel. The province has attempted to balance the needs of the producers to meet international competition with its own goals of ensuring that output is refined within Canadian borders.

At present the criteria used to arrive at an exemption are as follows.

- Production (ore concentrates, matte) in excess of domestic smelting/refining capacity occurs and a sales contract for the unprocessed goods can be obtained.

- No appropriate domestic processing facilities are available in Canada. This may arise either if the Canadian or global demand for these metals is small or if the technical facilities to refine and market them are not available in Canada.

- Ontario mines may produce material that Canadian refiners either are not equipped to process or cannot because of environment regulations. If the producer, then, is to realize some profit from the concentrates, he must contract with a refinery that has the required capabilities. These are generally located in Europe, the U.S. and Japan.

- A customer is unwilling to accept refined material (e.g. Japan).

- Other reasons include the particular needs of small mines, requirements set by lawsuits, etc.

The main motives behind granting exemptions, as can be seen by reviewing these criteria, are centred around market-driven considerations. Although exemptions are available to all metal producers in Ontario, the main awards have been given to base metal producers. Precious metal producers and custom refiners refine virtually all ores mined within Canada. Ferrous metal production is similar, although some exemptions have been awarded. However, iron ore or pellet exports have typically been offset by ore and pellet imports into the province. Such exchange is usually due to smelters' requirements for properly blended feed.

Copper-Zinc

Copper-zinc mines have refinery facilities in Canada. However, by-products such as lead, tin and refined residues are not treated in Canada and are shipped abroad along with some excess production.

Nickel-Copper

Exemptions for these metals differ widely among producers. Falconbridge continues to ship, by exemption, nickel-copper matte to its refinery in Norway. The reason for this exemption stretches back many decades. Three of the company's six mines were severed from Crown lands after 1917. The company commenced operations at Sudbury in 1928 and purchased a refinery in Norway owned by the Kristiansands group. A licence was required, as

well, for the Hybinette refining process used by the Norwegian refinery. The main argument for exemption has centred around the cost-effectiveness of overseas refining as opposed to building domestic facilities.

Inco refines over four fifths of its concentrates in Canada. With the exception of Japan – to which it ships nickel matte today only from Indonesia – overseas refining is done at Clydach facilities in Wales or in Acton, England. The latter refines precious and platinum group metals. Virtually all of Inco's by-product gold is now refined in Canada. For various reasons, mainly centred around market conditions, Inco has continued to receive exemptions for refining part of its production in its English refineries, or occasionally to export very small amounts of unrefined production to Far East countries other than Japan.

Development of Domestic Processing Facilities in Ontario

In volume terms, the development of domestic processing in Ontario is largely concentrated in the base metals sector. Within this sector, the most far-reaching developments have been in nickel/copper. However, domestic processing of zinc and magnesium has expanded in the last two decades. Ontario also refines much of its precious metal and uranium production.

The chronological order is as follows.

Copper/Nickel

1890 Canadian Copper Company built its first smelter at Copper Cliff.

1903 Orford Company merged with Canadian Copper Company and expanded its smelting capacity (in 1902 these two companies merged to form Inco).

1903 Mond Company was operating a smelter at Victoria.

1913 Mond Company opened a copper smelter at Coniston.

1918 Inco commenced its new nickel electro-refining operations at Port Colborne, near a cheap source of electricity (Niagara Falls) and the Welland Canal.

1930 Inco, American Metal Company and Consolidated Mining and Smelting Company formed the Ontario Refining Company and opened a refinery at Copper Cliff.

1930 Inco, which had merged with Mond in 1929, opened a new smelter at Copper Cliff. Falconbridge commenced limited production at its smelter in Falconbridge.

1955 Inco opened an iron ore recovery plant to produce iron sulphide for the production of an iron pellet for use in steel-making at Copper Cliff.

1960 Falconbridge began production of iron oxide. The initial plant was shut down in 1969 when a new plant to produce a reduced nickel-iron pellet and elemental sulphur commenced operation. This plant was shut down in 1972 because it was not economically viable.

1972 Inco opened, at Port Colborne, its foundry additives plant to supply the foundry industry with nickel-containing materials.

1973 Inco opened a high-pressure carbonyl-process refinery at Copper Cliff to produce nickel pellets and powder.

1977 Inco's subsidiary, Canadian Alloy, opened in Sudbury a rolling mill for the direct rolling of metal powders for the manufacture of nickel and cupro-nickel alloy strip for coinage. This subsidiary makes coin blanks for the Canadian Mint and mints of other countries.

1983 Inco opened a refinery at Port Colborne to produce cobalt.

1984 Inco rationalized its production, concentrating electrolytic nickel production at Thompson, Manitoba, pellets and powders at Copper Cliff and utility-grade nickel at Port Colborne.

1987 Inco converted a hydrometallurgical research plant at Port Colborne to refine precious metals, producing a platinum group metal concentrate and gold and silver sands. These facilities were developed in response to OC 3470/80.

It is difficult to discern a clear pattern of factors influencing domestic processing in this group of metals. Certainly, the initiation of refining (as opposed to smelting) in 1918 was driven by technological factors – development of the electro-refining process, and lower energy costs. Changes during the Great Depression were more market-driven. In the period 1950-70, development of new processes seemed to be technologically driven, while depressed market conditions of the early 1980s reshaped the industry through mergers and rationalization of production. These can be seen as cost-cutting exercises. Changes in the extent and character of domestic processing, this brief summary suggests, have been driven largely by technology and market forces. Section 104 contributed to the environment within which these decisions were made. In fact, given the timing of events, implementation of Section 104 can be seen as much as a reactive as a proactive event.

Copper-Zinc (Timmins)

1965 Texas Gulf Sulphur Company began the milling of copper-zinc ore at Kidd Creek Mine.
Initially, copper concentrates were both smelted and refined by Noranda and zinc concentrates were sold and exported for treatment.

1972 A zinc refinery was opened in Timmins by Texas Gulf.

1981 Texas Gulf completed construction of its copper smelter and refinery operations at Timmins (this process was developed on the basis of technology used by Mitsubishi in Japan).

Here it is even more difficult to ascertain the factors motivating domestic processing. The suggestion, and it is only that, is that both government initiatives and long-term contracts with Crown agencies seem clearly important. For example, Kidd Creek was given an allowance for pre-production expenses incurred prior to January 1, 1965 through the Mining Tax Amendment Act. Attractive power rates from Ontario Hydro and competitive freight rates from the Ontario Northland Railroad on shipments of sulphuric acid were subject to negotiation.

Magnesium (Haley)

The explanation for magnesium production in Ontario is clear. Government intervention to assist in the war effort created facilities for producing this metal in the Province. During the second world war, the federal government built two magnesium plants – one at Haley, Ontario and the other at Arvida, Quebec. The plant at Haley was expanded during the postwar period to meet growing domestic demand for magnesium; and Falconbridge, which had acquired the operation from Ventures Ltd., sold it to Chromium Smelting and Refining Ltd., which later became Timminco Limited. The plant produces, among other metals, calcium and strontium.

The exogenous impetus for these facilities was not Section 104 or even provincial initiatives, but rather the pressures of war for a secure domestic supply to meet the needs of aircraft production. Prior to 1939, the world's production of magnesium had been located in Germany. What is interesting is that once established, production continued long after the initial need came to an end. In trade theory terms, an infant industry which needed subsidies for its creation eventually "grew up" and operated on its own.

Precious Metals

Gold

Most gold mines produce a bullion which can be forwarded for purification at refineries in Canada.

Silver

The case of silver refining is more complex than for gold. Until 1972 silver, the only metal mined in the Cobalt area, was refined in this town by Cobalt Refineries Ltd. With the closure of this plant in 1972, silver-bearing concentrates had to be exported.

In 1972, however, the Canadian Smelting and Refining Corporation commenced construction of a refinery in Cobalt. Silver refining at this plant began in 1974 and has continued until recently. Inco refines its silver in its Ontario Division. Silver from Kidd Creek is refined by Noranda in Montreal.

It is difficult to come to any clear conclusions on what motivated silver refining in the province. The suggestion is that the volume of silver-bearing concentrates was sufficiently large and geographically concentrated to yield economies of scale that ensured normal profit at existing prices. Section 104 may have played a role, but this appears to be a case where natural advantages dictated domestic rather than foreign refining.

A list of smelting plants and refineries operating in Canada in 1988/89 is shown in Appendix A.

Conclusion

Although one cannot say with certainty what factors induced expansion of domestic production, it appears that market forces and technological change were key elements in this process. Section 104, in the main, appears to have played a passive rather than an active role in setting the extent and timing of greater domestic processing of metals in the province.

If we were to sort out the weight of market (demand and supply) forces from government intervention in setting this pattern, then we should have to answer the question: How would the observed pattern of domestic production have differed from what we have observed if there had been no Section 104? The data do not exist to test this counterfactual condition and so we are left with the suspicion that probably market forces, supplemented by the existence of Section 104, were relatively more important.[4]

---

[4] Although we explore the theoretical implications of Section 104 in the next chapter, it is worth mentioning that governments are always involved in trade-offs when decisions about intervention must be made. The principal rationale for Section 104 is that it will increase the value added to mineral commodities exported from the province. Enhancing value added has the effect of raising the total value of any given quantity of material exported. In a world of growing trade barriers against the import of more refined or processed products, governments must assess the impact these have on potential exports. It might have a smaller effect on the total value of exports to reduce the refining requirements in such a circumstance [see Ronald Jones and Barbara Spencer, "Raw Materials, Processing Activities and Protectionism", *Canadian Journal of Economics*, XXII no. 3 (August, 1989)]. However, such a direct effect, i.e. maintaining the total value of exports, must be weighed against the secondary linkage implications of expanding a more sophisticated manufacturing component in the industry as a whole. To date, the Ontario government has taken the broader and longer-term view of having Section 104 as an operating provision for mining in the Province.

3. Theoretical Analysis of the Domestic Processing Provision

The previous chapter outlined the action taken by the Government of Canada and the Province of Ontario to induce domestic refining of nickel. The initial approach by the former was to impose an export tax on unrefined material leaving the country for processing elsewhere. This approach was abandoned, and the response of the Province was to impose a domestic processing requirement on all lands severed after 1917. The contention here is that the domestic processing provision is analogous to an export tax, except that it operates as a quantity effect rather than as a price effect.

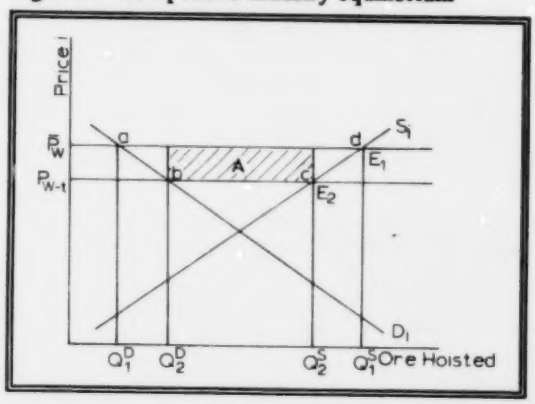
Export Tax

The simplest way to begin is with the effects of imposing an export tax on a given commodity. In undertaking this analysis we assume that the industry is competitive in the economic sense, i.e. domestic producers are price-takers; in other words, prices are imposed on the producers. This assumption may not agree with our knowledge of how prices are set for certain metals. However, with rising world competition in this industry over the last decade, such an assumption does not do great violence to our understanding of how this sector operates.

Figure 1 sets out the normal supply and demand relations in a competitive industry. D_i and S_i represent domestic demand and supply, respectively, of a given metal, "i"; P_w is the world price for the particular metal and we assume for the particular metal "i", the government imposes an export tax of "t" on this commodity. Such a tax cannot affect the world price paid by foreign buyers.

At the world price of P_w, the equilibrium (E_1) output of domestic ore producers is Q_1^S. The domestic demand at this world price is Q_2^D. Hence the amount exported is "ad" or $Q_1^S - Q_1^D$. When an export tax is imposed, the immediate effect is to reduce the price received by the producer on amounts exported.

Figure 1. Competitive industry equilibrium



In Figure 1, the effect of this is

- to reduce domestic output from Q_1^S to Q_2^S (at the new equilibrium point, E_2);
- to increase domestic demand from Q_1^D to Q_2^D;
- to *lower* exports from ad to bc (i.e. to $Q_2^S - Q_2^D$).

Government revenue increases by the amount represented in rectangle A. How much change occurs is, of course, a function of the price elasticity of demand and supply for the particular commodity.

The effect desired by the government is to induce more domestic processing. This is done by lowering the price received by the producer who exports the unfinished product; and by reducing the feed stock cost (or input cost) to the domestic processor of this raw material.

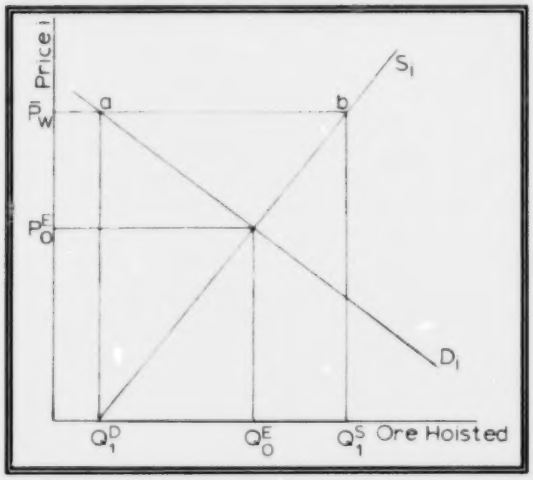
The latter, under these provisions, then buys raw material at a lower price, P_{w-t}, than the international price, P_w. It is the hope of the government that this lower price will induce the producer to invest in refining processes, thereby expanding local production, employing more people, and generally raising the level of sophistication in the industry. It is

assumed that such refining or further processing will encourage adoption of the best-practice technology since it is clearly in the interests of the producer to sell some of these refined products on world markets. It is also hoped that gains achieved by further processing are not negated by reductions in domestic mine output, such as would occur if S_1 were much more elastic (flatter) than D_1.

Domestic Processing Conditions

The Province shifted in 1917 to the current prohibition on export of unprocessed ore or concentrate unless exempted. This is equivalent to a quantity restriction on the export of raw ores. The effect of such a quantity approach is shown in Figure 2.

Figure 2. Impact of quantity restrictions on exports



In this case, unlike the export tax approach (Figure 1), the effect is to lower the price to the internal equilibrium point for domestic production (P^E_O). Here the effect on the industry is much more dramatic than in the export tax case. Of course, the two cases could be made equivalent by imposing a tax equal to $\bar{P}_W - P^E_O$ (Figure 2).

Before the imposition of the "Domestic Processing Conditions", exports were ab ($Q^S_1 - Q^D_1$), as in the case shown in Figure 1. Now, however, exports fall to zero, i.e. equilibrium price is P^E_O and quantity is Q^E_O and the "price effect" for domestic producers is much greater.

Under the quantity constraint approach, the price (P^E_O) is set by the supply conditions of the industry, i.e. quantity of ore raised, costs of production; and the level of domestic demand. The latter, after imposition of Section 104, now represents the demand by refiners for the raw material. This is set by demand conditions for the "refined" product at home and abroad.

Since the equilibrium price under these conditions is lower than under the export tax provisions, at least as assumed here, there is even greater inducement to invest in domestic processing facilities. Notice, however, two direct consequences of this approach:

- *First, domestic production is much less than under either the "free market" or the export tax conditions.*

- *Second, the government does not receive any revenue, as it did under the export tax provisions.*

It is clearly the hope of the government that induced expansion in the refining sector will create more jobs than are lost in decreased mining production, and that the taxes on the profits earned will at least partially, if not fully, offset the loss of revenue in the absence of export taxes.

This explanatory approach is stated in analytical terms, which means that it describes the hypothetical case of a rigidly applied quantity constraint. Nevertheless, it does suggest the direction of change that emerged from the imposition of the conditions set out in Section 104 including provision for exemption from the Mining Act, and the application of this section in the real world of Ontario's mineral sector. The government, as always, must examine the trade-offs between competing goals. Clearly, the Ontario government believed that, over time, the Section 104 amendment would create more employment and more sophisticated technical development in the industry than would be the case if the industry were unregulated and hence allowed to sell its raw product anywhere at the existing world price.

It has for some time been widely suggested - both in industry and in government circles - that Section 104, if challenged, would fall, both on Canadian constitutional grounds for being *ultra vires* the province as legislation affecting international trade, and under the GATT as a situation paralleling the B.C. Fish Processing Case. As no challenges have occurred, the issue remains unresolved both in

occurred, the issue remains unresolved both in Canadian courts and in the GATT Tribunal. In addition, it will be interesting to observe how the FTA with the U.S. will affect this provision in the Mining Act.

Economic Rationale for Section 104

Economic theory would suggest that welfare is maximized when market forces are allowed to operate without restriction. The passage of Section 104 violates this basic tenet since, as shown in Figures 1 and 2, domestic supply and demand are shifted from the levels that would emerge in the absence of such intervention and price, for domestic producers of ore, is lower than would be the case, other things being equal, if they were allowed unfettered access to world markets for raw materials and concentrates.

What justification, then, is there for this intervention? We are dealing with a non-renewable resource. The term "non-renewable resources" is a conventional shorthand for the wide variety of metallic and other (e.g. fossil fuels, industrial minerals, structural materials) mineral resources in the ground which have not yet been recovered or even discovered. The term must not be narrowly interpreted as it tends to obscure a few other very important aspects of such resources, which deny them a crucial economic characteristic (long-term rising real price to infinity) which a truly "non-renewable resource" would have to exhibit. A consumable non-substitutable resource is always renewable. Other implicit assumptions underlying the term (analytical construct) are fixed technology, fixed relative prices and a non-spatial economy. In the narrow sense, "non-renewable resource" is a contradiction in terms.[4]

Under these conditions we expect, in the short run, surpluses to accrue to the owner(s) of the resources as long as price exceeds marginal cost. The question is: Who gets these surpluses? Clearly, the province and its residents should share in such returns. It is assumed, for the sake of argument, that such surpluses (returns to land) can be clearly distinguished in practice from returns to other factors of production such as capital, labour, entrepreneurship.

Governments have long recognized that some of these surpluses could be exported with the raw material unless certain steps were taken.[5] The Ontario government at the turn of the century was simply following a long tradition of encouraging the processing of raw materials prior to their export. It was attempting to ensure that some of the temporary surpluses would "stay at home", in spite of the risk, for a time, of possible disincentives to capital investment inherent in such a policy. The policy was a rational stance in the province's "infant industry stage" during a rapid growth period of the world economy.

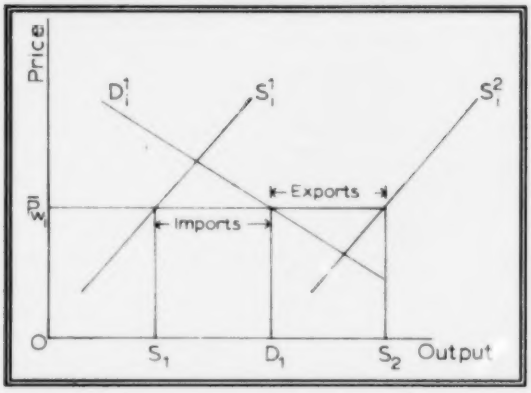
As we saw earlier in the chapter, intervention took the form of prohibiting the export of unrefined mineral and metal products. Figure 2 showed that the effect of this was to lower the feedstock price to the refiners below its international level. The effect, then, was a carrot and a stick: a carrot to the refining industry, through an indirect subsidy in the form of lower input price; while the stick was the threat of losing mining rights to lands from which unprocessed ores were exported.

The goal, as we have stated, was to induce investment in the refining sector. We can see the consequences of this in Figure 3. Initially, Ontario producers exported the raw material; it was refined out of the country and some of the refined product was imported for use in domestic production. This is the condition that we see with demand and supply curves D_i^1 and S_i^1 in Figure 3. These are demand and supply curves for the refined mineral or metal. At the world price of $\bar{P}_{w_i}$ the country imported D_1 minus S_1 of the commodity. It produced domestically OS_1. With investment in refining induced by the introduction of Section 104, and technological developments like cheaper energy costs (hydroelectricity), domestic production expanded. This is seen in the shift of the supply curve from S_i^1 to S_i^2. Domestic output has increased from OS_1 to OS_2 and

[4] See Andrews, Gramm, Maurice: *Does Resource Conservation Pay?* Los Angeles, 1978.

[5] In the 16th century, for example, anyone found within 25 miles of the coast of England in the possession of raw wool was arrested and had one hand cut off, since it was presumed the individual was engaged in exporting wool. The government of the day was attempting to foster the growth of a domestic wool textile industry.

Figure 3. Economic effects of an export tax



the country now exports (at $\bar{P}_{w_1}$) S_2 minus D_1 of the refined product, earning foreign exchange (as compared to the initial case, spending foreign exchange).

Besides earning foreign exchange, expansion has generated employment (with the higher level of output) and investment represented by the shift in the supply curve. This result is similar to that expected when a tariff is imposed on an import. The justification for the tariff is based on the infant-industry argument: i.e. provide some initial protection from lower-priced overseas producers until the local industry can grow sufficiently to provide cost-effective competition. As indicated by its name, the infant-industry argument becomes redundant once an industry has achieved maturity, and it may then be countered by protective measures of a new generation of developing economies. As we see, the result in Ontario follows this model closely. The refining industry has not only grown to meet domestic needs but is an important exporter as well.

4. Manufacturing Component of Ontario Metal Mining Activity: Aggregative Analysis

The previous chapter set out the theoretical implications behind the decision by the Ontario government to adopt Section 104 of the Mining Act. As we saw, the main effect was to lower input costs of raw materials to the domestic refining sector, with the long-term goal of enticing the industry to expand its production capacity in processed and semifabricated products.

This chapter focuses on the growth of smelting and refining activity in the province. Can we find a pattern which suggests that Section 104, in addition to market forces, has played a role in expanding production of higher-value added commodities? In addition, we make a preliminary assessment of the impact of smelting and refining on expansion of employment and income.

Composition of Exports by Degree of Manufacture

The basic motive of Section 104 was to redirect the processing of ore mined in Ontario from overseas to domestic Canadian producers. In essence, the provincial government, through this provision, wanted to reduce the amount of mined material being exported in its raw or unprocessed form and hence increase the value-added element of the commodities sent to other countries.

Table 1. Percentage of exports of ores and concentrates to total exports[1], by individual metal from Ontario

	Nickel	Copper	Zinc
1975	41.3	12.0	48.9
1981	34.7	16.9	13.0
1985	40.8	15.9	9.5

Source: Statistics Canada Cat. #65-003, Table 3.
[1] Total exports = (ores, concentrates, scrap) + alloys

To provide some perspective on the distribution of exports by degree of manufacture, Table 1 was constructed. This table shows the ratio of the value of ores and concentrates exported to total metal exports from the province at three points of time: 1975, 1981 and 1985. These ratios were calculated for three metals - nickel, copper and zinc - and should be treated as lower-bound estimates on the degree of domestic processing. For example, the numbers include matte with concentrates, and do not distinguish between Ontario ores that are processed in other provinces.

The first point to note is that for all three metals the share of exports requiring a higher degree of manufacturing was greater than 50 percent; i.e. less than half (by value) the metal exports leaving the Province were in a relatively unprocessed form. In fact, with the exception of zinc exports in 1975, copper and zinc exports shares in ore and concentrate form represent less than 15 percent of total exports for these two metals.

The trend for zinc provides an excellent example of how government policy can dramatically alter the composition of exports. In the previous chapter, we noted that Texas Gulf Sulphur Co. was encouraged to build a zinc refinery in Timmins. As an inducement not directly related to Section 104, the government offered the company specific processing allowances and discounts (e.g. lower electricity costs and mining taxes). The company began construction of a refinery in 1970 and production commenced in 1972. The result, as column 3 of Table 1 shows, transformed the composition of exports for this commodity. In 1975, almost half of all zinc exported was in a relatively unprocessed state. By 1985, ores and concentrates accounted for less than 10 percent of all zinc exports, and over 90 percent was in higher-value-added form. This is a clear example of the effectiveness of Section 104 when it is combined with specific financial inducements.

Nickel and Copper Exports

The shares of low-value exports for nickel and copper are almost trendless over the study period (1975 to 1985). The higher percentage of unrefined exports for nickel reflects the exemptions obtained by Falconbridge (see discussion in Chapter 2) to use its Norwegian refinery for processing matte.

Table 1 provides us with an interesting view of how Section 104, supplemented by government inducements, can affect the degree of domestic processing. The exemptions for Falconbridge and the new zinc refinery at Timmins show how the composition of exports is affected by government policy.

Manufacturing vs. Mining in Ontario Metals

The amendment to the Mining Act was very specific in terms of its goals. It was intended to increase the share of all ores and minerals raised that were treated and refined in Canada. The purpose was to increase the ratio of smelting and refining or the manufactured component, relative to basic mining activity.

In order to get a perspective on the amount of value added in Ontario smelting and refining relative to value added in mining, Table 2 was constructed. Once again, these ratios are lower-bound estimates since steel, nonferrous metals and gold are combined, thus lowering estimates of value added in mining.

Two points emerge from this exercise. First, in terms of value added (gross value of production minus purchased inputs, i.e. materials and supplies plus energy), the smelting and refining industry in the province is between 15 percent and 20 percent of the mining sector. The share of total manufacturing output in total gross domestic product in Canada is about 20 percent. Hence the share of smelting and refining in Ontario is not substantially different from that of all manufacturing activity.

The second point to note is the absence of any trend over the last quarter-century. Although there is some variation about the mean level, the amplitude of this variation is quite small. This is probably not unexpected, since the mining output is the input to the smelting and refining industry. The absence of a trend suggests that by the early sixties, with the exception of zinc (see the previous section), the balance between provincial refining and mining activity had become established. There has been no relative shift towards greater smelting and refining, at least within the province.

We should also note that in terms of value added per employee per year, mining is twice as "valuable" as smelting and refining and leads all other industrial sectors (see Table 3).

Table 2. Ratio of value added in smelting and refining to value added in mining for Ontario annually
1961-86

Year	Ratio (1)	Year	Ratio (2)
1961	.15	1974	.12
1962	.16	1975	.15
1963	.14	1976	.17
1964	.13	1977	.19
1965	.17	1978	.12
1966	.20	1979	.13
1967	.18	1980	.07
1968	.17	1981	-
1969	.16	1982	.22
1970	.17	1983	.16
1971	.24	1984	.13
1972	.19	1985	.15
1973	.12	1986	.16

Sources:
1. Smelting and Refining: Statistics Canada Cat. #41-214
2. Mining: Statistics Canada Cat. #26-223

Table 3. Value added per employee per year, 1986 (dollars)

Mining	58,700
Manufacturing	
Average	32,400
Chemical	48,100
Food & Beverage	37,300
Primary Metals	36,800
Transportation Equipment	32,800
Forestry	29,200
Woodworking	20,200
Agriculture	19,100

Source: *Canada Year Book*, 1986.

Geographical Distribution of the Smelting and Refining of Ontario Ores

Figure 4 sets out the percentage of total metals mined in Ontario that are refined in Canada. Recall that the original intent of Section 104 was to impose an export tax on ore shipped out of the province for refining elsewhere. At that time (early 20th century), this really meant out of Canada. Certain constitutional problems prohibited such an imposition and so the current arrangement was adopted. Essentially, the BNA Act prohibits a province from interfering directly with inter-provincial trade and hence the amendment to the Mining Act can induce mining companies to refine in the province (e.g. zinc) but ore mined in the province is free to move to other provinces for refining. As we can see in the chart, the share refined outside of Ontario has risen since the early 1970s. It might be noted that regional development incentives in the Mining Tax Act have been adopted to promote further processing in northern Ontario.

As one can see from Figure 5 and Table 4, the share of ore mined in Ontario and refined in Canada varies widely for different ores. In the case of silver, gold and copper, virtually all ores mined in Ontario now are refined in Canada. In the case of nickel and cobalt, only about half is refined in this country.

The distribution between refined inside and refined outside Canada for a number of metals has shown a strong upward trend since the late sixties. Again note the case of zinc: the sharp upward share refined in Canada after 1978 reflects the incentives accorded to the industry in constructing a refinery in Timmins.

Figure 4. Percent of Ontario mine output refined in Canada
Source: Mineral Statistics Section, Ministry of Northern Development and Mines.

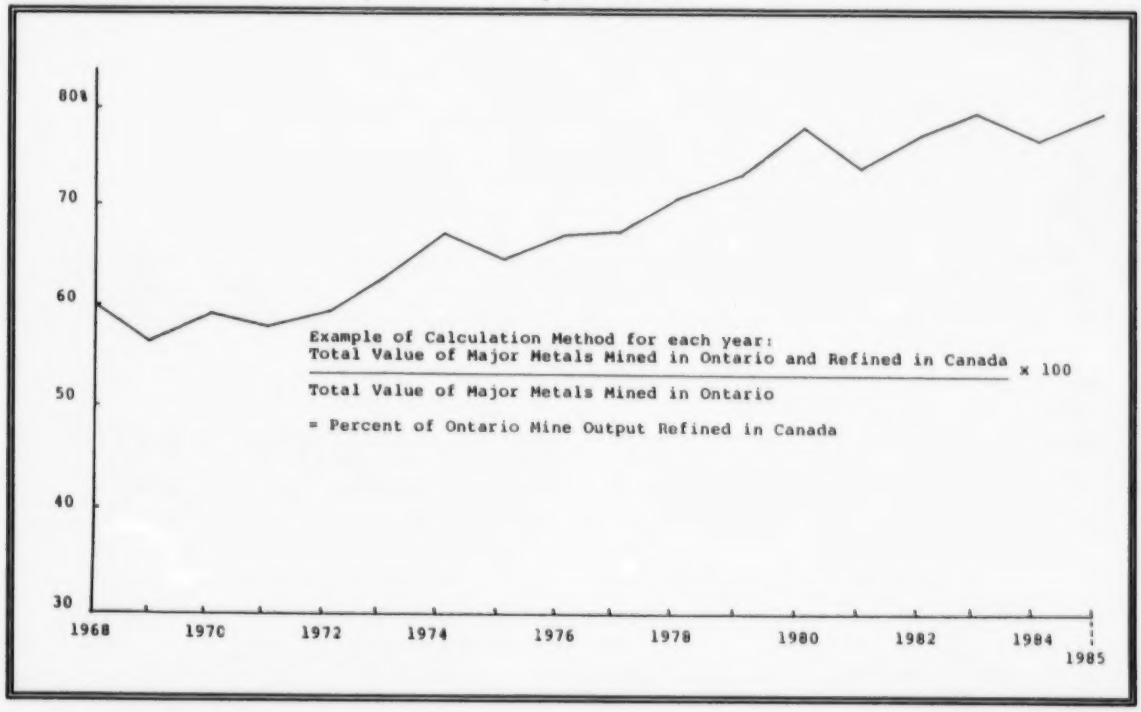


Figure 5. Major metals mined in Ontario and refined in Canada (as a percent of Ontario mine output)
Source: Mineral Statistics Section, Mineral Development and Lands Branch, Ministry of Northern Development and Mines.

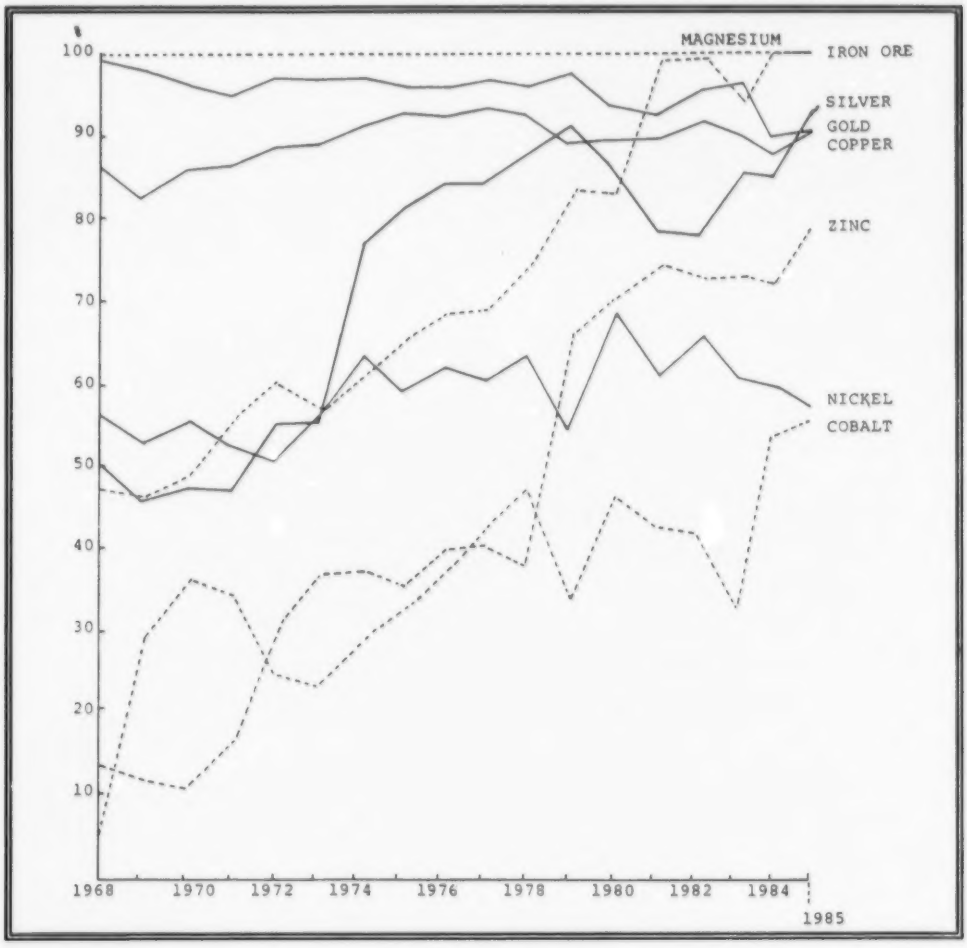


Table 4. Selected major metals mined in Ontario and refined in Canada as a percentage of Ontario mine output
1981-87

	Silver	Gold	Copper	Nickel	Lead	Zinc
1981	78.3	92.9	89.8	59.4	3.9	74.8
1982	77.2	96.7	91.5	64.8	8.0	72.6
1983	86.5	96.1	90.0	56.4	61.8	73.0
1984	84.8	88.1	87.9	58.0	3.6	72.2
1985	92.0	89.9	89.5	56.4	6.5	77.7
1986	86.6	92.4	91.3	59.6	9.3	79.9
1987	88.9	98.2	92.8	58.5	28.6	83.4

Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, Mineral Development Lands Branch.

The other interesting case is silver, which follows a trend similar to zinc except that similarity is due to the influence of the opening of the Kidd Creek Mine, Canada's largest silver producer. By 1987 almost 90 percent of the silver mined in Ontario was refined in Canada. The break in trends coincides with the opening of The Canadian Smelting and Refining Corporation operation in Cobalt.

Table 5 sets out the geographic distribution of smelting and refining of ores mined in Ontario.

Copper-Nickel

As Table 5 shows, virtually all of the copper and nickel mined in Ontario is smelted in Canada. For copper about two thirds, rising to three quarters, is smelted in Ontario while for nickel 100 percent of the ores mined are smelted in the province. In the case of copper, the share smelted in the province has increased sharply since 1978.

The geographical distribution of refining between the two metals also differs. Over four fifths of copper mined in Ontario is refined in Canada, while for nickel over 40 percent is refined outside of Canada with the balance being refined in Ontario.

The data, then, reveal that there has been a shift towards a greater share of processing of copper within the Province during the last decade. Again, this sharp rise coincides with the opening of a copper smelter and refinery in Timmins in 1982. Here, as in the case of zinc, the shift follows government policy initiatives.

Lead/Zinc

The trends for lead and zinc processing, and especially for lead, are quite interesting. In the case of lead, there has been a distinct separation between the smelting and refining functions. In the early 1970s, over four fifths of all processing was done outside Canada. By 1985, only two thirds of the ore was smelted in the province but over 90 percent was refined outside of Canada. The value of production of lead as a by-product in 1985 was only $2.2 million, hence the shifts are interesting but the impact on the economy is minor.

Zinc production has already been discussed. The only point to make here is that, unlike lead, there is a close link between where the ore is smelted and where it is refined. A shift towards greater share smelted also raises the amount of ore refined in the Province. The government incentive to zinc producers then had a potentially strong "pay off" in terms of generating employment and income in the Timmins area.

Silver/Gold

For silver, a dramatic increase in smelting and refining within the Province coincided with the opening of a refinery at Cobalt in 1982. As noted earlier, this has since closed. For gold, virtually all the ore is refined in the province. Both bullion and doré are considered final products.

Employment and Income Effects

The basic goal of Section 104 is to increase the share of mineral processing activity carried out within the Province. The more processing done and, hence, value added in the Province, the greater the anticipated spin-off to the Ontario economy as a whole and to the northern regions in particular. Governments in Ontario since the turn of the century have been committed to expanding and stabilizing economic development in all regions of the Province.

Inherent in this strategy, however, is a possible conflict. On the one hand, the government is interested in expanding employment. On the other hand, the companies must produce refined products that are internationally competitive, which means minimizing production costs wherever possible. One way to minimize costs is to substitute capital for labour, since historically the cost of labour has risen relative to the capital costs.

The connection, then, between the initiation of a new activity such as a smelting and refining plant and regional development is quite complex. One can think of growth set in motion by a new activity as depending on what Perloff *et al* [6] have termed its "activity interaction potential". This refers simply to the input-output ties of the new activity with other activities within the same region and elsewhere.

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[6] Harvey Perloff et al, *Regions, Resources and Economic Growth* (John Hopkins Press, Baltimore, 1960), pp. 93 ff.

Table 5. Smelting and refining – Ontario mine production, 1971-1987

	Silver						Gold					
	Smelting			Refining			Smelting			Refining		
	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada
1971	9.9	37.0	53.0	9.9	37.0	53.0	92.7	2.5	4.9	92.7	2.5	4.9
1972	9.8	45.4	44.8	9.8	45.4	44.8	93.8	3.2	2.9	93.8	3.2	2.9
1973	8.3	47.5	44.2	8.3	47.5	44.2	93.8	3.3	2.9	93.8	3.3	2.9
1974	10.3	66.5	23.2	10.3	66.5	23.2	93.7	3.4	2.6	93.7	3.4	2.6
1975	10.6	70.9	18.5	10.6	70.9	18.5	92.7	3.5	3.8	92.7	3.5	3.8
1976	14.1	70.2	15.7	14.1	70.2	15.7	87.9	8.0	4.0	87.9	8.0	4.0
1977	19.7	66.7	13.6	17.9	66.7	15.4	86.3	10.1	3.6	86.3	10.1	3.6
1978	17.3	71.9	10.8	16.2	71.9	12.0	84.8	10.2	5.0	84.8	10.2	5.0
1979	13.5	80.4	6.1	11.0	80.4	8.6	87.0	10.6	2.3	87.0	10.6	2.3
1980	17.4	70.4	12.3	15.4	70.4	14.2	84.0	9.6	6.4	84.0	9.6	6.4
1981	21.9	59.8	18.2	18.5	59.8	21.7	84.8	8.1	7.1	84.8	8.1	7.1
1982	26.8	50.6	22.6	26.6	50.6	22.8	87.9	8.7	3.3	87.9	8.7	3.3
1983	18.2	70.1	11.8	16.4	70.1	13.5	88.8	7.3	3.9	88.8	7.3	3.9
1984	20.5	64.3	15.2	20.5	64.3	15.2	77.2	10.9	11.9	77.2	10.9	11.9
1985	44.3	47.7	8.0	44.3	47.7	8.0	84.2	5.8	10.1	84.2	5.8	10.1
1986	37.0	49.6	13.4	20.5	66.1	13.4	66.6	25.8	7.6	66.6	25.8	7.6
1987	41.8	47.1	11.1	22.9	66.0	11.1	68.7	29.5	1.8	68.7	29.5	1.8

Source: "1988 Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch.

Table 5. Smelting and refining – Ontario mine production, 1971-1987 (continued)

	Copper						Nickel					
	Smelting			Refining			Smelting			Refining		
	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada
1971	64.8	31.7	3.4	31.7	31.7	13.2	100.0	0	0	52.5	0.0	50.0
1972	63.5	34.5	2.0	34.5	34.5	11.2	100.0	0	0	50.6	0.0	51.2
1973	65.8	32.4	1.8	32.4	32.4	10.9	100.0	0	0	56.6	0.0	45.8
1974	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100.0	0	0	63.9	0.0	38.5
1975	63.2	36.4	0.4	56.5	36.4	7.2	100.0	0	0	59.0	0.0	43.5
1976	63.5	36.1	0.4	56.6	36.0	7.4	100.0	0	0	62.1	0.0	40.3
1977	59.0	40.6	0.4	52.6	40.6	6.8	100.0	0	0	60.7	0.0	42.0
1978	50.3	49.2	0.5	43.3	49.2	7.6	100.0	0	0	63.6	0.2	340.5
1979	43.4	56.4	0.2	33.2	56.4	120.4	100.0	0	0	53.9	0.3	47.2
1980	59.8	40.0	0.2	49.9	40.0	10.1	100.0	0	0	66.5	2.6	32.7
1981	60.2	39.4	0.4	50.4	39.4	10.2	100.0	0	0	59.4	1.5	40.6
1982	54.8	44.8	0.4	46.7	44.8	8.5	100.0	0	0	65.7	0.0	35.2
1983	66.3	33.5	0.1	56.5	33.5	10.0	100.0	0	0	60.3	0.1	43.6
1984	74.7	22.8	2.4	65.1	22.8	12.1	100.0	0	0	58.2	0.1	42.0
1985	76.7	22.0	1.4	67.6	22.0	10.5	100.0	0	0	56.5	0.6	43.6
1986	78.1	20.7	1.2	70.6	20.7	8.7	100.0	0	0	50.1	9.5	40.4
1987	77.5	19.5	3.0	71.1	21.7	7.2	100.0	0	0	53.3	5.2	41.5

Source: "1988 Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch.

Table 5. Smelting and refining – Ontario mine production, 1971-1987 (continued)

	Lead						Zinc					
	Smelting			Refining			Smelting			Refining		
	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada	% in Ontario	% in Other Provinces	% Outside Canada
1971	-	18.8	81.2	-	18.8	81.2	-	16.9	83.1	-	16.9	83.1
1972	-	31.4	68.6	-	31.4	68.6	14.9	15.1	70.0	14.9	15.1	70.0
1973	-	57.2	42.8	-	57.2	42.8	23.5	13.7	62.8	23.5	13.7	62.8
1974	-	59.7	40.3	-	59.7	40.3	32.4	15.2	62.4	32.4	15.2	62.4
1975	2.7	35.2	62.1	0	35.2	64.8	25.1	10.9	64.0	25.1	10.9	64.0
1976	2.8	34.1	63.3	0	33.9	66.1	30.9	9.1	60.1	30.9	9.1	60.1
1977	5.4	15.4	79.2	0	15.4	84.6	28.0	12.9	59.2	28.0	12.9	59.2
1978	3.7	26.9	69.4	0	26.9	73.1	26.3	11.9	61.9	26.3	11.9	61.9
1979	7.0	75.6	17.4	0	75.6	24.4	36.6	29.7	33.8	36.6	29.7	33.8
1980	4.4	61.8	33.8	0	61.8	38.2	40.1	31.2	28.8	40.1	31.2	28.8
1981	37.4	3.9	58.6	0	3.9	96.1	44.4	30.4	25.2	44.4	30.4	25.2
1982	56.8	8.0	35.2	0	8.0	92.0	40.5	32.0	27.4	40.5	32.0	27.4
1983	38.2	61.8	0.0	0	61.8	38.2	36.2	36.7	27.0	36.2	36.7	27.0
1984	57.1	3.6	39.2	0	3.6	96.4	41.4	30.9	27.8	41.4	30.9	27.8
1985	61.1	6.5	32.4	0	6.5	93.5	47.9	29.9	22.3	47.9	29.9	22.3
1986	32.5	9.3	58.2	0	9.3	90.7	44.5	35.4	20.1	44.5	35.4	21.1
1987	20.5	28.6	50.9	0	28.6	71.4	40.5	42.9	16.6	40.5	42.9	16.6

Source: "1988 Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch.

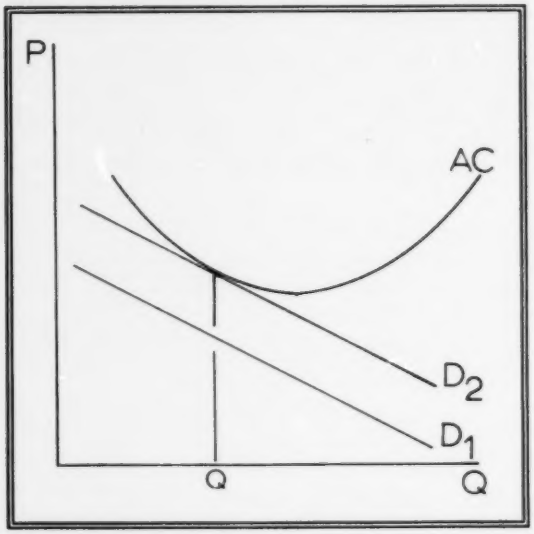
We normally think of three types of linkages in this connection: backward (to suppliers); forward (to upstream production and higher value added); and demand (expansion in general demand associated with increased employment and income).

Section 104 was introduced to provide an incentive for increased forward and demand linkages. Smelting and refining are the obvious forward linkages from metal mining. Expansion of the core industry (mining) does not bring with it an automatic expansion of the metal-consuming industries. This is a behavioural link and so will depend both on reducing the cost of the input (ore) *and* on the market potential for the output (i.e. the refined product).

This is very different from the backward linkages, which are much more automatic and hence more easily predicted. Thus, as output of the ore industry expands, it needs greater inputs. Increased demand for the latter induces investment in their production. The two cases (forward and backward linkages) can be shown diagrammatically as in Figures 6a and 6b.

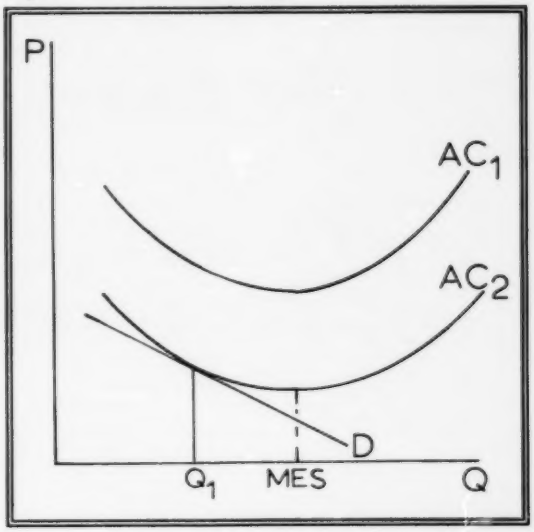
In the case of backward linkages (Figure 6a), mineral expansion shifts the demand curve for a particular input (widgets) from D_1 to D_2. The D_2 demand curve intersects with the average cost curve for widgets and production becomes profitable.

Figure 6a. Backward linkages



In the case of forward linkages (Figure 6b), the effect of the expansion of ore production, and in our case the reduction in the price of the feedstock (ore), is to lower the average-cost curve from AC_1 to AC_2 where the latter intersects with D_2, the demand for refined metal. At this point, if we know where D_2 lies, production commences. However, there is no guarantee that this will occur, since it presumes the existence of a domestic (or foreign) market sufficiently large to yield the necessary economies of scale. In other words, the market must be large enough to bring the producer close to the minimum efficient scale (MES) of production.

Figure 6b. Forward linkages



Backward Linkages: Smelting and Refining

Table 6 sets out the purchases of materials and supplies and energy by the Ontario smelting and refining industry, annually, from 1961 to 1986.

The estimates suggest that the smelting and refining sector plays an important role in generating demand from other sectors. If we assume a multiplier effect of 2.5, by the mid-1980s this implies that the "spill-over" effect is about $500 million. Not all of this goes into the Ontario economy since energy purchases, for example, for natural gas and oil, have implications for non-provincial suppliers; clearly, the share of energy relative to that of material and supplies has shifted dramatically (substitution effect).

Table 6. Purchases of materials and supplies and energy by the smelting and refining sector, Ontario
1961-86
(millions of current $)

Year	Materials & Supplies	Energy	Total
1961	87.7	20.5	108.3
1962	97.8	18.0	115.8
1963	67.8	16.7	84.5
1964	49.5	18.5	68.0
1965	46.6	22.4	69.0
1966	47.8	21.6	69.4
1967	40.4	23.6	64.0
1968	48.3	26.1	74.4
1969	36.3	18.8	55.1
1970	49.1	29.9	79.0
1971	45.4	35.3	80.7
1972	41.7	29.4	71.1
1973	51.1	32.0	83.1
1974	60.5	39.8	100.3
1975	55.4	45.2	100.6
1976	61.8	59.7	121.5
1977	73.3	63.8	137.1
1978	59.8	61.7	121.5
1979	65.4	64.1	129.5
1980	n.a.	n.a.	n.a.
1981	n.a.	n.a.	n.a.
1982	84.5	63.2	147.7
1983	71.9	89.6	161.5
1984	85.1	108.7	193.8
1985	109.5	111.2	220.7
1986	103.3	104.7	208.0

Source: *Smelting and Refining*, Statistics Canada, Cat. #41-214
n.a. - not available

The other point to note is how dramatically the backward linkage effect has increased between the mid-1960s and the period after 1975; the impact is, in fact, double after 1975. These data suggest that decisions made earlier can have an important effect on the present and the future.

To provide some perspective on the size of this linkage, consider its value relative to a crude estimate of the regional income. The region[7] is defined as Sudbury-N.E. Ontario (Nipissing, Timiskaming, Cochrane, Sudbury, Manitoulin and Algoma) plus Lakehead-N.W. Ontario (Thunder Bay, Rainy River and Kenora). The authors suggest that this region's share of total Ontario disposable income is approximately 11.5 percent (1986), or $23.6 billion.

As suggested above, the total backward linkage (i.e. purchases by the smelting and refining industry) by the mid-1980s was about $500 million, or approximately 4 percent of the assumed total regional income of the North, as defined above. This one sector alone then represents a significant contribution to demand for inputs. If similar figures were available for a finer regional breakdown, such as the Timmins area, one suspects that the impact would be quite large. Hence, we see the reason for the desire by the government to induce such production into the area.[8]

Final Demand Linkages

In addition to this demand for materials and energy, the industry creates direct demand for consumer goods and services. One way to measure this is through the industry's wage bill, i.e. the total wage and salary income paid to employees in the sector. Table 7 sets out the wage bill for our study period.

As Table 7 shows, by the middle of the decade, incomes from this sector were about $143 million per year. This represents more than a three-fold increase over the early 1960s. If we assume a multiplier of 2.5, then it implies an impact of $360 million on the Ontario economy. This represents labour income, and labour is concentrated in specific towns and cities where the impact of this income, therefore, is substantial. Column 3 of Table 7 shows wages adjusted for prices. The deflator used is the Consumer Price Index. Since we are interested here in the purchase of goods and services by employees in smelting and refining, standardizing nominal wages (column 2) by an index of consumer prices provides the appropriate measure of change in real purchasing power.

[7] Camu, Weeks and Sametz, *Economic Geography of Canada*, Macmillan, Canada, 1964, p. 370-71.

[8] At this point it is not possible to remove the effects of such firms as Stelco and the Royal Canadian Mint from these figures. These estimates therefore must be taken as preliminary.

Table 7. Wage bill for the Ontario smelting and refining sector
1961-86
(millions of current and constant $)

Year	Amount	
	Current	Constant
1961	45.1	142.7
1962	41.9	130.9
1963	35.1	107.7
1964	40.1	120.8
1965	49.4	145.3
1966	47.8	135.8
1967	59.6	163.3
1968	60.5	159.2
1969	44.2	111.3
1970	72.0	175.6
1971	77.3	183.2
1972	68.9	142.9
1974	87.9	166.5
1975	71.9	122.9
1976	99.3	157.9
1977	104.9	154.5
1978	77.8	99.3
1979	73.4	96.4
1980	122.3	137.6
1981	n.a.	-
1982	111.1	100.3
1983	133.0	113.5
1984	144.4	118.1
1986	143.1	108.1

Source: *Smelting and Refining*, Statistics Canada Cat. #41-214
n.a. – not available.
To convert to constant $ terms the Consumer Price Index (1981 = 100) was used – see Appendix B Table 1.

Employment Impact

Besides adding directly to regional income, the goal of Section 104 is to generate more employment in the Province. Table 8 shows total employment in the smelting and refining sector from 1961 to 1986.

Table 8. Employment in the smelting and refining sector, for Ontario
1961-86

Year	Number	Year	Number
1961	9,322	1974	8,468
1962	8,748	1975	6,518
1963	7,132	1976	7,819
1964	8,112	1977	7,780
1965	9,250	1978	4,396
1966	9,034	1979	3,976
1967	9,323	1980	n.a.
1968	9,031	1981	n.a.
1969	6,876	1982	4,663
1970	9,532	1983	4,970
1971	9,321	1984	5,163
1972	7,791	1985	4,983
1973	6,871	1986	4,800

Source: Statistics Canada Cat. #41-214
n.a. - not available.

This industry over the study period has clearly downsized. Average employment in the sixties and early seventies ranged between 7,000 and 9,500 employees. By the 1980s, this had declined to close to 5,000, a drop of almost a third.

This sharp decline in average employment, beginning shortly after the OPEC oil crisis in 1974, is partly due to the slowdown in demand for metal in the following decade and partly, especially in the 1980s, due to decisions by producers to increase the efficiency of the industry in the face of rising costs and stiff international competition. The joint effect has been to extinguish direct employment increase. However, with higher levels of capital intensity, more jobs are moved from direct employment into contracting. The result is that the industry has survived and, as we saw in Tables 6 and 7, sharply increased its income impact on the province.

To assess how labour productivity has changed, Table 9 was constructed. This table divides the deflated wage bill by employment. The deflator is the metal price index (see Appendix B, Table 2). Economic theory states that

$$W_n = MPP_L \times P_i$$

where

W_n = nominal or current $ wage
MPP_L = marginal physical product of labour
P_i = price of the commodity i.

Hence, by simple division,

$$\frac{W_n}{P_i} = MPP_L$$

Thus the ratio calculated in Table 9 is a crude measure of labour productivity.

Table 9. Index of average real wages in the Ontario mining and smelting industry 1961-86 (1970 = 100)

Year	Average Real Wage	Year	Average Real Wage
1961	1.16	1974	0.82
1962	1.06	1975	1.00
1963	1.06	1976	1.14
1964	.88	1977	1.14
1965	.85	1978	1.25
1966	.80	1979	1.00
1967	1.06	1980	n.a.
1968	1.04	1981	n.a.
1969	.93	1982	1.33
1970	1.06	1983	1.42
1971	1.29	1984	1.50
1972	1.32	1985	1.59
1973	0.98	1986	1.65

Source: see Table 5 and Appendix B Table 2.
n.a. - not available

The table shows a very distinct upward trend, especially beginning in 1982. This is in sharp contrast to the desultory performance of labour productivity from the early sixties to the mid-seventies. Thus there has been a trade-off between job creation and efficiency, with increased efficiency the clear winner. This sector, therefore, has sought to offset higher cost of production with greater labour productivity. It illustrates the general rule that, if the cost of one factor of production (here labour) increases significantly (for the producer) relative to another (here capital), then substitution of the latter for the former will take place.

Greater labour productivity implies that more, and better, capital has been supplied to the labour force. This is important for our discussion of the *activity interaction potential* of this sector. Sharply increased investment expenditure means spillovers to the machinery industry in Canada. Purchases of this equipment create expansion in the machine tool sector, assisting the latter to keep adapting the best practice technology.

Implications

The evidence presented above shows clearly that encouragement of mineral processing and semi-fabrication production in the Province of Ontario has had an important effect on regional development. This impact has come through the linkages created between the mining sector and the smelting and refining sector, and between the mineral producers and other economic sectors in the Province – in particular, the equipment suppliers and industries providing consumer goods to the employees. Although employment in the two mineral sectors has declined, real wages in these sectors have increased and hence the total impact has been an important element of regional development. Total impact includes both direct consumption and the indirect or multiplier effects that emerge as a result of the expansion of both basic mining and processing activities.

5. Long-Run Analysis of Domestic Processing Activity[9]

Introduction

The previous chapter examined changes in the smelting and refining industry over the last quarter century. It revealed some important changes in the extent of this activity within the province. This chapter shifts the focus of the discussion in two directions:

- to a longer period;
- to differences between unit values and base metal prices.

The object is to determine what factors may account for shifts in the ratio of unit prices to base metal prices. Were they driven by market forces (demand) or by changes in product mix (technology)? To anticipate the discussion, the main finding is that deviations between these two price measures are due to a mixture of demand and product mix factors.

Definitions

The core of the analysis in this chapter is the trend, and trend breaks, in the ratio of unit to world metal prices. The numerator (unit prices) and denominator (world metal prices) are defined as follows:

[9] The basic data used to calculate the figures shown in this chapter were derived from extensive detailed work on volume and value of metal production by individual commodity type for the period 1900 to 1987 done by Dr. Gerry Anders, Chief Research Analyst, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines. The authors wish to express their thanks for the work Dr. Anders put into calculating these series.

Unit Price (or cost)

$$\textit{Unit Price}_i = \frac{\textit{Value of Production}}{\textit{Volume of Production}} = \frac{(\bar{P}xQ)_i}{P_i}$$

where

$\bar{P}$ = metallic product price
Q = quantity of metallic product sold
i = metallic product (i.e. for each metal, such as copper, nickel, lead, etc., the line of products sold at different prices).

The value of production includes all sales of the metal producer from ore concentrate or matte to his range of refined products. For example,

$$\bar{P} \times Q = (a.P_1Q_1 + b.P_2Q_2 + \ldots mP_nQ_n)$$

where $\bar{P}$ for each metal represents the weighted average of prices realized by an Ontario mine producer over the whole range of his primary products. P_1Q_1 is the sales value of a particular product and P_2Q_2 is the sales value of a different product, etc. Clearly, the greater the value added for each product, the greater will be the sales value of all products. The composition of output, as measured by the shares of the various P_iQ_i's (i.e. the weights are a,b,c,...m) will change over time as market forces and technological change alter the product mix.

It is the contention here that, overall, the weighted sum of the products showed a major increase coincidental with the introduction of Section 104. If the values are rank-ordered from the lowest to the highest value (i.e. P_1Q_1 is the least value added and P_nQ_n the highest value added), then the existence of Section 104 expands the scope of production undertaken.

Movements in the scope of production after the introduction of Section 104 will therefore depend on market forces. As we outlined in the previous chapter, Section 104 is a passive element: the active agents are market competition and technological

change. These two agents affect the short-run impact of Section 104 on the scope of production.

Metal Price

The price of refined metal (of standard specification, unchanging over time) is that recorded on the London Metal Exchange. It is this price that is used as the numeraire against which unit costs are compared. This price represents the basic refined metal cost to the buyer. It does not embrace processing to higher diversified specifications that may take place as we observed in the unit price ratio. Thus we expect $\bar{P} < P$ whenever the bulk of a metal is exported as ore concentrate or matte and $\bar{P} > P$ when higher stages of refinement or product differentiation predominate.

The ratio, then is

$$\frac{UNIT\ COST}{METAL\ PRICE}, \quad i.e. \quad \frac{\bar{P}}{P}$$

An increase in this ratio implies that, other factors being equal, the amount of domestic processing has increased as the scope of production has expanded towards products of a higher value added. Such a shift is consistent with the intent of Section 104.

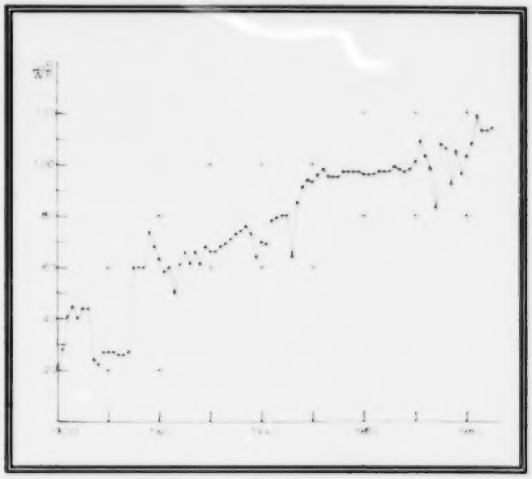
What follows in the chapter are a few examples – nickel, copper, zinc and lead – of how this ratio has changed over long periods of time. An attempt is made to offer a preliminary explanation of the forces (demand versus supply) that influenced shifts or traverses in the index of unit costs to metal prices.

Nickel

Figure 7 shows the ratio of unit value to the market price of nickel for the period 1900 to 1986. As mentioned above, the time path of this ratio is not smooth; rather, it takes two major jumps, one during World War I and another in the late 1940s. Between these discontinuities, the ratio is more or less trendless, although some short-run fluctuations occur. We will deal only with the two major breaks.

The first break occurs in 1915. This is not an accident. With the outbreak of hostilities, demand for nickel accelerated. For a number of reasons, particularly security of supply, it was decided to refine nickel in Canada, and accordingly nickel refining commenced in 1916 at Port Colborne, Ontario. As mentioned earlier, this shift towards more domestic processing coincided with the development of the electrolytic nickel refining process and the reduction in electricity costs. The upward shift marks a major realignment of production from off-shore to domestic refineries. It was about this time (1917) that Section 104 came into force.

Figure 7. Nickel - ratio of unit price to world price, 1900-1986



It is difficult to untangle which of these factors – expanded market demand due to the war, technological change, reductions in electricity costs, or the pending introduction of Section 104 – dominated the decision-making process of the producer. However, the industry at this point entered a new development path, one where production externalities were clearly present, which reduced the cost of domestic processing for Ontario mines.

The next major break occurred in the 1940s. At first glance, it appears to have taken place after the end of World War II. However, this interpretation could be misleading, since the Canadian dollar was devalued right after the war and this caused a major dip in the series. If one takes a slightly longer view, there is evidence that the break occurred *during* WWII, rather than after the war ended. If this view is taken, then we come back to the factors identified earlier, at the time of WWI. There appears, then, to be a widening in the scope of production in response to the nature of demand during the war. What is interesting is that, once a higher plateau

has been reached, there is no return to earlier levels.

In the 1940s the motive for change is clear: the need for a safe, cost-effective supply of nickel to match the expanding needs of the military. The industry responded and actively set itself on a new development path. Demand factors seem to have been more dominant during WWII, rather than the mixture of factors suggested in the case of WWI. Certainly there was no change in the legislation that might explain the shift towards higher levels of domestic production. It should be noted that part of the rise in 1939/40 and the dip in 1946 may be due to the cessation and then resumption of Falconbridge matte shipments to Norway. During the war, this matte had been processed by Inco.

Finally, the most recent upward shift in the ratio apparently began in the late 1970s, with the main increase coming in the early eighties. Although it is too early to make definitive statements on the cause(s) of this shift, any list must include increased market competition that has, until very recently, forced down the price of refined nickel. When this occurs, it is clearly in the interest of the industry to seek ways of widening (versus deepening) the market for nickel. New shapes, different refined products, etc. are all part of this response to price reductions.

This upward shift in the scope of higher value-added production can be seen in Figure 7. Beginning in the mid-seventies, the ratio of unit price to metal price moves up sharply, from a value of 0.84 in 1974 to 1.14 in 1986. Can we, then, observe changes in the value of commodities produced over this period?

Table 10 was constructed as a partial test of this contention that nickel producers were increasing the amount of value added in their total sales. This table was constructed by obtaining the shares of individual commodity quantities and values in total output for the nickel industry. Commodities whose share in value exceeded their share in output are, by definition, higher-value products. These products shares were totalled and are shown in Table 10 for four years, 1970, 1975, 1980 and 1987.

The share trend shows a distinct break between the 1970s and the 1980s. The higher shares in the 1980s indicate that, on average, the industry was producing a greater share, in quantity terms, of products whose value exceeded the average value for *all* goods. This, as mentioned above, parallels the results shown in Figure 7 for the trend between the mid-seventies and the mid-eighties.

Table 10. Share of relatively high-value products, nickel

Year	Share
1970	46.1
1975	42.0
1980	53.6
1987	55.7

Source: Appendix B, Table 5.

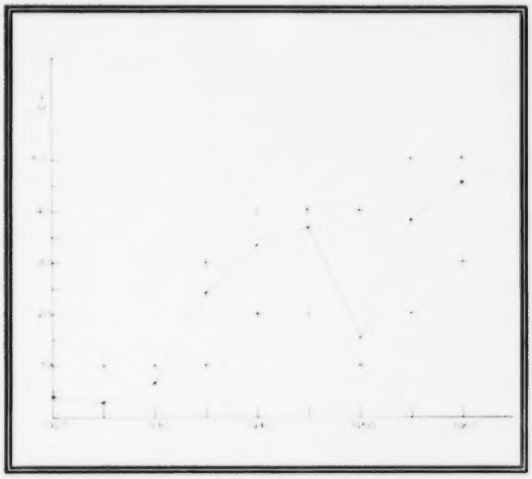
We are hard-pressed to determine with precision the actual reason for this shift. However, it is interesting to note that it corresponds closely to the change in international market conditions for nickel. After 1974, world nickel markets went into what turned out to be a long period of adjustment. Although conditions have improved recently, the changes we observe in Figure 7 and Table 10 were clearly undertaken during weaker markets for nickel. Apparently, the response of the industry to these conditions was to widen the scope of goods produced, and to shift thereby to commodities of higher-than-average value added. It may well be that Ontario producers enjoyed a comparative advantage in their production, and so it was an effective way to compete.

Finally, central to this whole discussion is the impact of Section 104 on the changing composition of exports and imports. Using nickel as an example and moving to early decades (the period of the introduction of Section 104 – see the shift in the unit/market price index after 1910 in Figure 7), we have constructed an index based on the ratio of total nickel exports to total nickel imports (Figure 8).

One measure of the success of Section 104 is that the value of exports should rise relative to the value of nickel imports, i.e. the average value added should increase relatively faster for exports.

This ratio has been calculated for selected years from 1920 to 1960. If we allow for the normal lag in start-up of new facilities, we see clearly from Figure 8 that the ratio begins to rise by the later 1920s and then increases rapidly through to the end of the era. The only interruption in this pattern occurs in the late 1940s (1945-50) and this is probably associated with disruption of international commodity markets following the end of the second world war. Overall then, using the ratio of export

Figure 8. Nickel - ratio of exports to imports, 1920-1960



to import values as a "measure" of the shift in production towards domestic manufacturers, Section 104 apparently had a positive impact on increasing value-added production within Canada (and Ontario). Since Ontario is the major producer of nickel in Canada, figures for Canada are a good indicator of the Ontario values.

Copper

Figure 9 shows the index of unit cost to metal price for copper annually from 1900 to 1986. It was constructed as described earlier in the chapter. In this case, the ratio begins to rise early in the century, takes a major upward shift after the passage of Section 104 in 1917, and thereafter climbs slowly, reaching a new level by the beginning of the 1930s. Thereafter, the ratio "cycles" around a level of approximately 0.90 with the greatest instability occurring through the thirties and forties. From the late 1940s until the early 1960s, the ratio averages about 1.0, with few deviations. Between 1960 and 1975, the ratio becomes highly unstable, with large cyclical swings, stabilizing at 1.0 for the decade after 1975.

What factors influenced these trend changes? Demand for copper, as for other metals, is a derived demand. Copper's properties of electrical and thermal conductivity, combined with its fatigue resistance and low creep factors, make it an excellent metal for use in electrical equipment. Its corrosion resistance makes it an excellent material for naval applications and it is used for small-calibre ammunition as well as in aircraft and missile applications. Hence its demand is sensitive to changes in the construction cycle (buildings), wars, and general capital expenditure in the transport and communication sectors.

In the early years, the pattern changes for reasons similar to that discussed for nickel: the introduction of Section 104, cheaper energy costs, and war demand. Once the investment had been made in the smelting and refining sector, the product mix was altered permanently. Deviations about the new trend line represent divergence between the quantity-weighted distribution of goods produced and the London Metal Exchange (LME) price of copper. In the 1960s and early 1970s, the LME price moved sharply ahead of the unit cost, returning to parity in the 1970s as copper prices declined. This segment of the industry went through a once-and-for-all transformation during and immediately after WWI.

In recent decades, the main threat to copper in the wiring market has been the rise of aluminum wiring. Recognizing this potential rival and intent on attempting to maintain its market share in this area, the industry created the Copper Promotions Producers' Committee (C.P.P.C.) in 1960, which has been known since 1965 as CIDEC – Conseil International pour le Développement du Cuivre.[10] Its object was "to promote in all countries the use of copper, its alloys and components".[11]

Sir Ronald Prain, writing in the mid-1970s, quotes an industry observer's comment that copper producers have ignored the uses to which copper is ultimately put. Copper producers have been more concerned with new orebodies and the latest extraction techniques. Marketing of the metal, with rising competition from aluminum and plastics and especially from fibre optics, therefore is a strategy to which the industry must turn. As described in Chapter 6, nickel marketing is now being promoted vigorously by the Nickel Development Institute (NiDI), a worldwide body like CIDEC. The latter, although unquestionably effective, has apparently not had a major impact on the degree of manufacturing component in Ontario, at least as revealed in Figure 9.

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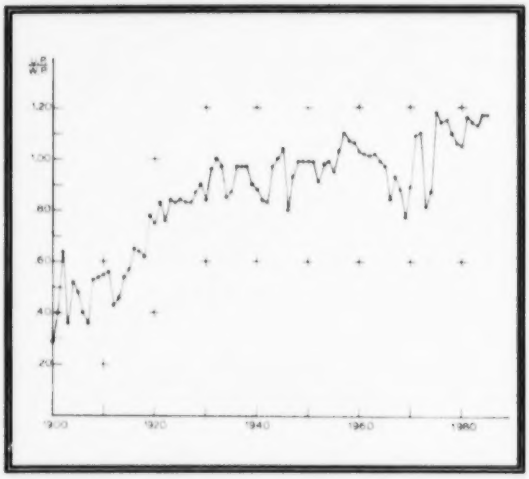
10 Sir Ronald Prain, *Copper: The Anatomy of an Industry*, Mining Journal Books Limited, 1975, Chapter 13).

11 *Ibid.*

Figure 9. Copper - ratio of unit price to world price, 1900-1986



Lead and Zinc

Figures 10 and 11 repeat the index of unit cost to price for lead and zinc. The value of lead and zinc produced is small relative to nickel and copper. Furthermore, the ratio of unit cost to price has been trendless for lead, cycling around 1.0. This has also been the case for zinc. It is worth recalling that a new zinc refinery was opened in Timmins in the early seventies.

The properties of zinc and lead are different. Zinc's important physical properties are its low melting point, high electrochemical activity, ease of alloying, high refractive index, and its opacity to ultraviolet rays. Lead, on the other hand, is among the softest of the metals, malleable and corrosion-resistant. The major use of zinc when alloyed with copper is in providing corrosion resistance to steel products through galvanizing; and this accounts for its use in high-quality paints. It is also used in the pharmaceutical industry, in the electronics industry and as additives for oils and grease. Lead's most important applications are in batteries and, to a declining extent, as an anti-knock additive to gasoline.

Because of the nature of end uses for the two metals, lead may be more sensitive to cyclical variations than zinc. This is the picture revealed in annual index changes (Figure 10). The only conclusion one can draw is that market forces (rather than technological factors within the industry) appear to be the driving factor behind changes in the index.

Precious Metals

Silver and gold indices for the ratio of unit cost to metal prices are shown in Figures 12 and 13. The ratios cover the period from 1900 to 1986.

For both metals, the index is trendless over long periods, and cycles around 1.0. This is to be expected. In the case of gold, the mines produce bullion, most of which has been purified at refineries in Canada for many years. Silver metal was produced until quite recently at Cobalt and is now produced by Inco's Ontario Division, while Kidd Creek silver is refined at Montreal. The only break in production occurred in 1972, but refining was resumed in 1974. There is no difference, at least over long periods, in the ratio of unit cost to metal price, as one might expect.

All-Metals Index

Figure 14 draws together the indices for individual metals in one series. The ratio shown is the unweighted average for nickel, copper, zinc, lead, gold and silver. As the preceding discussion has outlined, the annual movement among metals differs. Hence this "blended" index represents the combination of demand and supply factors that influenced the individual metals.

The "all-metals" index indicates that a major break in the ratio of unit price to LME metal price occurred in the years around the time of passage of Section 104. Except during the second world war, the index was relatively flat, cycling around a mean of about 0.95. The "all metals" index confirms again the effect exerted by the introduction of Section 104 in 1917. This legislation apparently had a direct impact on the extent of domestic processing of raw material in the province at the time it was enacted. After the resulting initial structural shift, further changes were due more to specific market (demand) and technological (supply) factors than to Section 104.

Figure 10. Lead - ratio of unit price to world price, 1900-1986

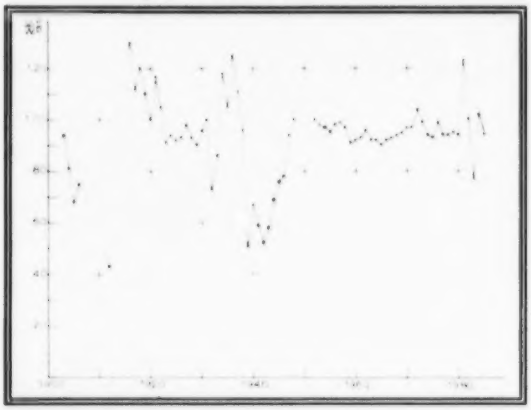


Figure 11. Zinc - ratio of unit price to world price, 1900-1986

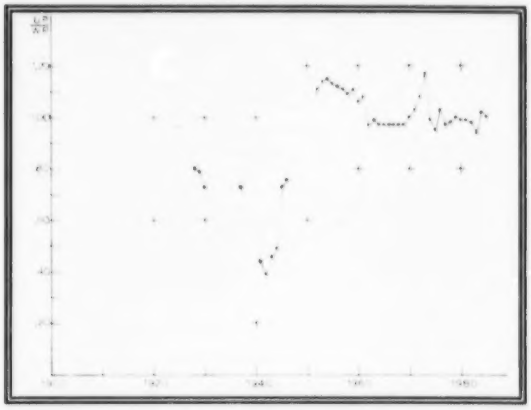


Figure 12. Silver - ratio of unit price to world price, 1900-1986

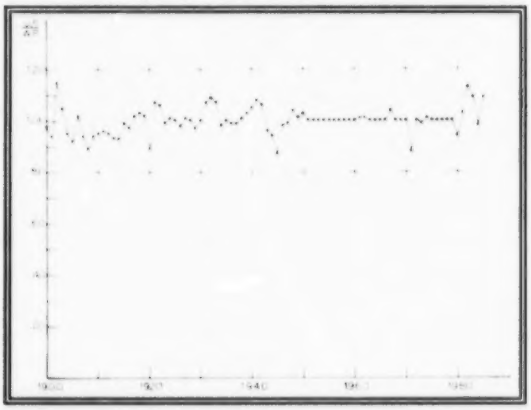


Figure 13. Gold - ratio of unit price to world price, 1900-1986

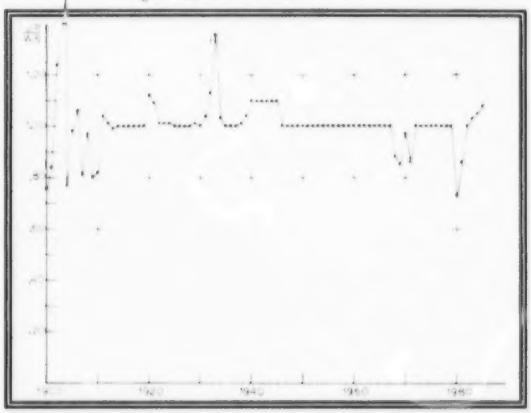
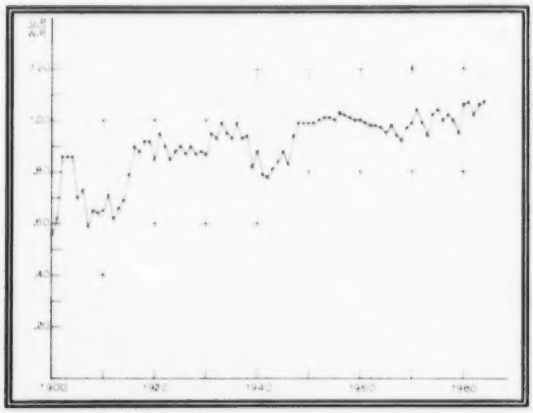


Figure 14. All metals average - ratio of unit price to world price, 1900-1986



Conclusions

This chapter explored time trends in the ratio of unit costs to LME metal prices for nickel, copper, lead, zinc, gold and silver for the period 1900 to 1986. It was the contention that increases or traverses in these series (i.e. a faster increase in unit costs than pure metal price) were an indication of a widening in the scope of production (i.e. of an increase in the total value added). In other words, the share of manufacturing in total recorded sales had risen.

An increase in domestic production of the Province's mineral resources prior to export was the goal of the government in 1917 when it introduced Section 104 of the Mining Act of Ontario. Thus an increase in unit costs relative to LME metal prices, so the argument went, would be one indication of the effectiveness of government policy as defined in Section 104.

Our findings are quite straightforward. First, there is clear indication from the shifts in the ratio of unit costs to LME prices for nickel and copper that Section 104 did meet its objective: the degree of domestic manufacturing (value added) did increase. Second, this structural break set in motion a chain of reactions in the smelting and refining industry that brought the industry into line with best-practice global technology. Third, widening the shape of production had "spin-off", or multiplier, effects in other sectors, suppliers, new products, complementary industries that enhanced further income, and employment, not only in the North but in the Province as a whole. Collaborative measures (i.e. increased shares of high-value products in total nickel output) in the late seventies and early eighties, and trends in the ratio of the value of exports of nickel to the value of nickel imports, are consistent with the goals of Section 104. Finally, this exercise has shown that one is not justified in treating unit costs as equivalent to LME metal prices. Unit costs may, and often do, include a wider range of product values (i.e. products of a higher value added) that negate the assumption that the two indices are equivalent.

Finally, it must be stressed that while the theoretical analysis suggests Section 104 met its objective under "infant industry" conditions, the Ontario mining sector no longer is an infant industry. It remains an open question for which theoretical analysis cannot give an *a priori* answer whether, under today's mature industry conditions, enforced increases in levels of processing would offset losses in mining output, or whether it indeed did so under "infant industry" conditions.

6. Trade Negotiations and the Ontario Metal Mining Industry

Introduction

The previous chapter dealt with the impact of Section 104 of the Mining Act on the extent of domestic processing of metals in Ontario. It addressed two questions:

- What is the rationale for such a provision?
- What effect has it exerted on increasing the value-added content of metals exported from the province?

In general, Section 104 was seen as an export tax that was instituted to encourage more domestic processing – in essence, an "infant-industry" model. The "infant-industry" rationale, generally used in connection with import duties, suggests that initial protection to a fledgling industry is necessary to allow the new producers time to acquire sufficient economies of scale to get their production costs in line with offshore competitors. The growth of the Ontario smelting and refining industries can be seen as a response to this infant-industry model. Hence one can judge Section 104 as having, during its first decade or so, succeeded in achieving its main objective: that of encouraging more domestic production of raw materials mined in the province.

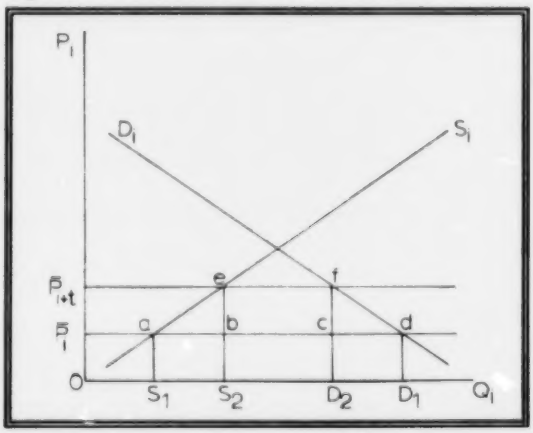
The successful operation of Section 104, however, depends not only on establishing a cost-effective processing sector in the provinces but also on the ability of these producers to gain access for their products to foreign markets. Although the statistics are difficult to obtain, it appears that 80 percent of Canadian mineral output is exported.[12]

This chapter shifts the focus of discussion from domestic production to external market access. Even if Ontario producers are as efficient as any in the world, their ability to sell abroad will depend partly on the willingness of potential foreign buyers to admit their products. High duties on mineral imports, particularly on our higher-value exports may extinguish part or all of our comparative advantage in these products. What, then, has been the international environment within which Ontario producers have had to compete, especially with regard to tariff barriers (and non-tariff barriers), and how has this situation influenced Ontario production? These are the concerns of this chapter.

Economics of Tariff Barriers

The economics of tariff barriers are set out in Figure 15. In this case, an examination is made of the impact on domestic processors of import tariffs on Canadian products imported to foreign markets – the reverse of the condition in the previous section, where the focus was exclusively with the impact of an export tax (Section 104) on Ontario production.

Figure 15. Economics of tariff barriers



[12] David Anderson, "Implications of the Canada-U.S. Free Trade Agreement for the Canadian Minerals Industry", *Resources Policy*, June 1988, pp. 121-134.

Figure 15 shows the supply and demand conditions in, say, Japan for commodity i (e.g. copper tubes or other processed copper products up-stream from concentrates). P_i represents the international price for copper tubes. In our case, this is the price of copper tubes at which Ontario producers could effectively compete and earn a "normal" rate of return for their efforts.

At price P_i, Japanese copper tube manufacturers would produce OS_1 and at that price Japanese copper tube consumers would purchase OD_1. The gap $OD_1 - OS_1$, or "ad" on the diagram, constitutes Japanese imports of copper tubes and would represent the market Canadian producers would supply; all or part, depending on the nature of competition.

Let us assume that the Japanese government imposes a tariff of t on the import of copper tubes. This changes internal and external market conditions dramatically. The new price to Japanese consumers has increased from P_i to P_{i+t}. This results in an *increase* in Japanese production of copper tubes from OS_1 to OS_2 and a reduction in purchases from OD_1 to OD_2. The gap between domestic production and domestic demand in Japan has declined from "ad" (no tariffs) to "ef" (with tariffs). Imports are now "ef" and much smaller than "ad". The market for Ontario producers has declined quite sharply.

The converse, of course, is quite different for Japanese producers. Local Japanese production is now OS_2. This means Japanese factors of production, capital, and labour have been drawn towards the production of copper tubes. Conversely, all other things being equal, these resources have been withdrawn from production in the export country (i.e. Ontario).

This simple diagrammatic representation shows clearly why Canadian producers are anxious to eliminate tariff barriers in products where they enjoy a comparative advantage. Non-tariff barriers can have the same effect. The main difference is they are "managed" and "behind the scenes", rather than explicit, as in the case of a duty.

The level of tariff (and non-tariff) barriers tend to increase with the degree of process of mineral imports. Import barriers to higher-processed mineral products may be seen as the mirror image of constraints to the export of unprocessed ores. In a simple two-country model, economic rationality would suggest that both barriers be dropped to increase efficiency.

Industry's Response to Global Events

Essentially, a duty on imports changes the distribution of supply between domestic and foreign producers. In particular, it substantially reduces the market share of foreigners in the protected market; in our case, the share of Canadian metal producers.

Tariffs on fabricated metal products are not new. Awareness of their existence, however, is not widely appreciated either by the public at large or, indeed, by the Canadian federal government. There is a strongly held belief that no tariff exists on metal exports. However, this situation in fact applies only to ores and concentrates. Metals, oxides and more fabricated components are often subjected to import duties. (A more complete discussion of these duties is set out in the next section.)

In addition to such tariff barriers, the industry has faced a major shift in demand for its products. The expansion of the 1950s and 1960s came to a sudden halt in 1975 with the steep rise in energy costs and then again with the deep recession of 1981/82. Both these events, plus the emergence of heavily subsidized Third-World metal producers, changed the whole nature of the international market, a significant event for Canada in view of the fact that 80 percent of mineral production is exported.

How has the industry responded to these exogenous events – tariffs on value-added products, higher energy prices, and subsidized Third-World competition? In a production sense, the answer is simple. Once the dimensions and persistence of these changes became evident, the industry embarked on a vigorous program of adjusting inputs to meet output levels and, in the eighties, investing vigorously to bring operations into line with best-practice technology.[13]

A more subtle problem is also emerging in terms of worldwide competition. By imposing higher duties on more processed products while allowing ores and concentrates to enter duty-free, developing countries are then able to process the minerals and sell the refined or more highly processed metal back on the international market. Improved efficiency of

[13] Alan Green and Ann Green, *Productivity and Labour Costs in the Ontario Metal Mining Industry, 1975 to 1985: An Update*, Ministry of Northern Development and Mines, "Mineral Policy Background Paper No. 25" (Toronto, 1987), Chapter IV.

processing in Canada has countered some of this discriminatory competition aimed at protecting the infant industries of developing countries; however, other strategies are needed.

The most important strategy to emerge has been the re-orientation of metal companies from being supply-driven to being demand- or customer-driven. In the past, customers took what the mining companies offered, while the mining companies focused on expanding production in response to a growing worldwide increase in consumption of metals. The demand-driven strategies have meant the development of a whole range of new products. Probably the most impressive response was the creation of the Nickel Development Institute (NiDI) in 1984 to promote sustained growth in the consumption of nickel. NiDI deals exclusively with the demand side of the metal market. The objective of NiDI is "to identify, develop, promote and define world markets for nickel".

The accomplishments of NiDI, under the current directorship of Dr. J.P. Schade, supported by most of the world's nickel-producing companies, has been impressive. For example, one of the first tasks of the Institute was to enhance the understanding among potential customers of the uses of nickel and nickel-containing steels and alloys, including their applications, properties and appropriate methods of fabrication. The basic purpose of this exercise has been to encourage end-users to use nickel in its various forms.

Stainless steel absorbs over 50 percent of primary nickel. Markets for stainless steel have been strong over the last decade, and the expectation is that the demand for stainless steel will grow at a rate greater than 3.6 percent per year to the year 2000. Expanding the uses of stainless steel would constitute an important factor in shaping demand for nickel. To ensure such expansion, for example in building materials, in automobile production, consumer goods, etc., will require the education of engineers and designers in specifics of the value of this product.

To provide some perspective on the long-term growth of nickel and stainless steel, Figures 16 and 17 have been developed by the NiDI. As Figure 16 shows, the long-term growth in demand for nickel experienced a break in 1975. For the next 6 years, the growth rate was close to zero. However, since 1982 the growth has regained its long-term rate of increase. Part of this recovery is undoubtedly due to the vigour of the capital goods and consumer products industries, but part is also due to the greater variety of uses of stainless steel, alloy steels, nickel alloys, etc.

In the case of copper, there has been a diversification of product, along with increased investment in existing plant and equipment. The fear that copper would out-price itself and so become little used now seems to be unjustified.

The main implication of widening the scope of metal production – whether it be an expanded use of nickel in automobile production or the creation of electrolytic nickel crowns (developed by Falconbridge to provide an alternative to sheared cathode squares for use in titanium baskets) or new methods of packaging products – is that this all involves greater and more sophisticated uses of capital and labour, i.e. greater value added. These changes are consistent with the strategy of focusing more on consumers' needs, and certainly directly affect other domestic producers, those involved in the forward-linkage effects outlined earlier. On the other hand, attempts to export these more expensive products and market them worldwide run into resistance which often takes the form of higher import duty rates.

Barriers to Trade

The trade policy of many countries, especially emerging Third-World countries, of imposing higher tariff rates on more processed products, i.e. those with higher value added, directly increases the effective rate of protection enjoyed by metal fabricators in these countries.

Effective Production

Figure 15 sets out the impact of nominal tariff protection. This assumed that a single tariff was imposed on a single commodity (copper tubes). However, production is carried out on many levels, from the raw material inputs to the finished product. It is possible to impose different tariff levels on each of the stages of production. The use of this policy is referred to as effective (vs. nominal) tariff protection.

Effective protection recognizes, then, the existence of multi-stage production, where no single producer has added 100 percent to the value of the finished product. The final producer uses purchased intermediate products, some of which are imported; for example, Japan imports copper matte and converts it to refined copper which is then transformed into final products.

Figure 16. Non-socialist world nickel consumption
Source: Nickel Development Institute.

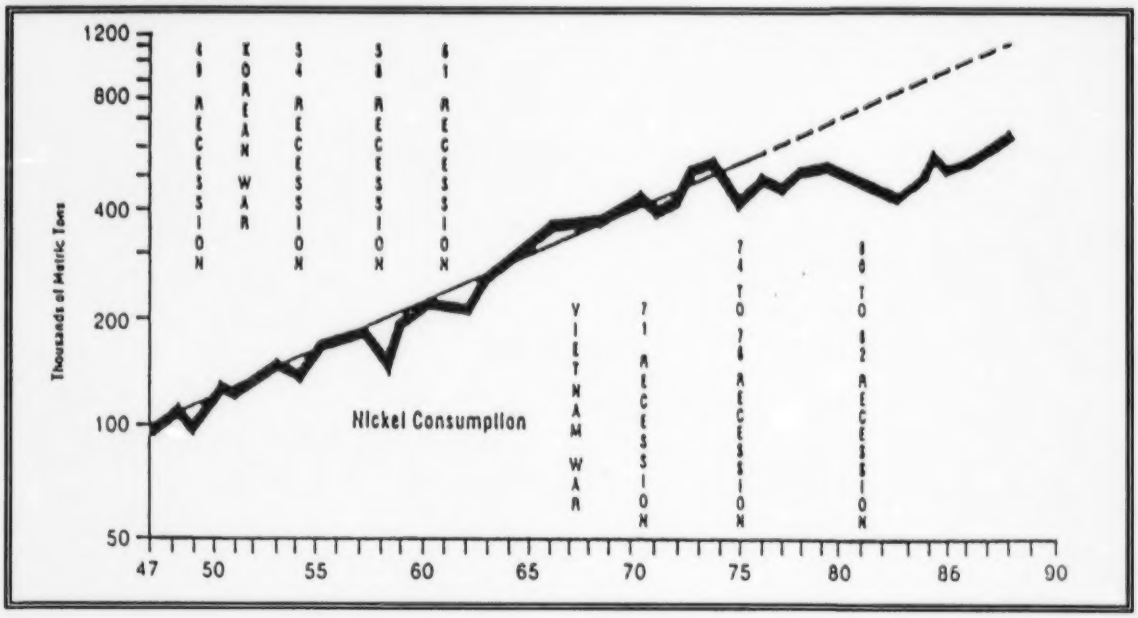
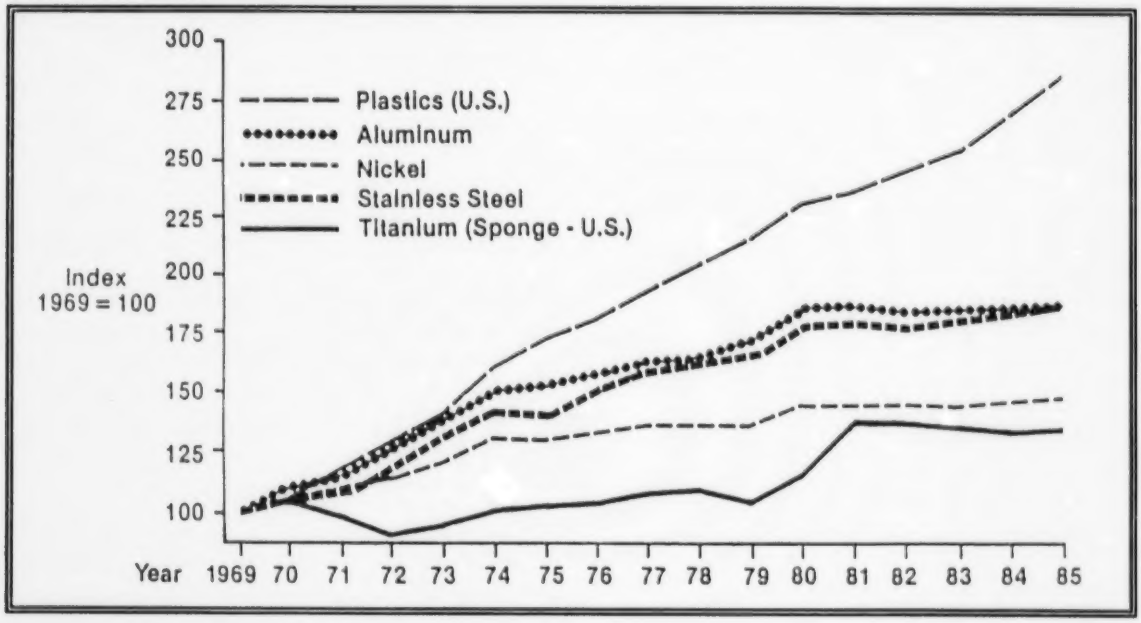


Figure 17. Growth rate of selected materials
(5-year moving average)
Source: Nickel Development Institute.



The *effective protection* that a given import substitute activity receives is as follows:

$$e_j = \frac{V_i^* - V_i}{V_i}$$

where V_i = value added per unit of final good i at free-trade prices

and V_i^* = value added per unit of final good i, at tariff-distorted prices. This effective protection is the proportionate difference between free-trade value added and tariff-distorted value added.

Effective tariff is, then, a function of three variables:[14]

- the nominal rate of tariff on the final goods;
- the nominal rate of tariff on the imported input;
- the share of imported inputs in the final good.

Although it may be difficult to actually measure effective protection, the underlying concept is quite simple. An import tariff on the final good i acts as a production subsidy to the local producer, while tariffs on imported inputs act as a production tax. Effective protection is a measure of the net effect of these two actions.

If a government imposes a high tax on imported final products but allows intermediate inputs to enter duty-free, then a large *effective* rate of protection is enjoyed by domestic producers. Conversely, a high tariff on intermediate inputs and a low tariff on final products imply a low level of effective protection.

In the previous example set out in Figure 15, primary resources (capital and labour) shifted towards production of the import substitute solely on the basis of an increase in the nominal tariff rate on the final goods (i). Extending the analysis to include tariffs on intermediate inputs makes the actual extent of resource reallocation towards this sector dependent on the net outcome of the three variables outlined above.

[14] David Greenway, *International Trade Policy* (Macmillan Education, London, 1988), p. 67.

Much recent discussion on effective versus nominal tariffs has centred on trade between less-developed countries (LDCs) and developed countries. LDCs claim that developed countries impose high effective rates, with high nominal tariffs on finished goods and low or zero tariffs on raw material or international inputs. This forces the LDCs to export only low-value-added exports.

It is interesting that, in the case of metal exports from Canada, the reverse condition appears to be the case. Countries such as Japan and other Asian countries, China, India, the East Bloc, and South American countries impose high nominal tariffs on refined metals but allow raw materials and concentrates to enter with low or zero duties, as part of their domestic economic policy to foster the growth of new industries.

As effective protection theory would suggest, the extent of the impact of this trade policy by these developing (or, in Japan's case, developed) countries will depend on the spread between nominal tariff rates on final goods and on intermediate inputs. There is no question also about the relative share of imported versus domestic intermediate inputs. In Japan's case, the domestic share is zero. In other countries, the share must vary according to the extent of domestic mining activity for the particular metal. Clearly, it would be instructive to measure these effective rates on a country-by-country basis. This would permit an accurate measure of the level of effective protection.

Before we actually examine some nominal tariffs on refined metal imports, a word should be said on the possible existence of *negative* effective protection rates. These may at first glance seem only pathological cases, but they actually exist, and they are not uncommon for exports. For example, a country might, for revenue or protection reasons, impose a high nominal tariff on intermediate inputs used by the export industry. If the country does not impose a production subsidy, then producers may face negative effective rates. Again, the effective rate on metal products for Canadian producers might be examined.

Examples of Actual Barriers to Trade

Calculation of effective protection rates on metal imports by country is a complex empirical exercise and so beyond the scope of this study. However, it

is useful to examine the nominal tariffs imposed by a sample of the countries mentioned above on mineral exports. Even this type of exercise ignores the complex range of tariff barriers imposed by countries on metal imports. In addition to increasing tariffs with value added, countries impose quotas or embargoes, or link the volume of imports to domestic need based on domestic production, thus fulfilling domestic demand before foreign supplies are allowed into the country.

Japan

Japan has historically practised a combination of sliding-scale prohibitive tariffs and embargoes related to domestic need. In the mining industry, Japan has structured imports of matte on the basis of LME quotation, while permitting Japanese metal processors to charge up to 15 percent more in the domestic market. The intention has been to provide a competitive advantage for Japanese metal processors in competing for raw materials from other countries. The impact on Canada has been to reduce investment in metal processing, because of the advantageous Japanese terms offered to Canadian mining companies. The benefit to Canadian west-coast copper miners over the years has been estimated at 5 cents per pound of copper. Specific duties on nickel imports to Japan are as follows.

Nickel Duties

- nickel metal sinter: Y72,900/MT or 11.7 percent *ad valorem* on CIF value, whichever is lower.
- ferronickel: 5.9 percent *ad valorem* on CIF value.
- nickel oxide sinter: 5.8 percent *ad valorem* on CIF value.

Imports from developing countries enjoy exemption from duty under the Generalized System of Preferences (GSP), as follows:

- nickel metal: Y36,450/MT or 5.85 percent *ad valorem* on CIF value, whichever is lower under monthly control system with flexible clause.
- ferronickel: duty-free for allocated quota.
- nickel oxide sinter: duty-free.

Additional problems are faced by Canadian suppliers since nickel metal imported from Zimbabwe and China enjoys a duty advantage greater than that given to Canadian producers. In other words, Japanese importers discriminate among suppliers.

Europe

The European Community operates very much like a club. It prevents imports of goods not wanted and escalates tariffs significantly on higher-value-added goods. The impact of final economic union in 1992 will clearly not diminish this "fortress Europe" attitude.

A sample of value-added taxes for Western Europe is set out below:

	Tax in percent
Germany	14.0
Belgium	19.0
Netherlands	20.0
France	18.6
U.K.	15.0
Austria	20.0
Switzerland	9.3 (dealers) 6.2 (direct users)
Norway	20.0
Sweden	23.5
Denmark	22.0
Spain	12.0
Portugal/Italy	(Not currently known)

There are transaction costs involved in exporting to Europe even if the Canadian producer establishes a European-based warehouse. The Canadian producer must pay the value-added tax (VAT) when the goods are put in the warehouse and is not eligible for a refund until the goods are sold. The rebate often takes a considerable length of time.

Also, Canadian exporters doing business in France require an import licence even for sales to

relatively small customers. This puts the Canadian supplier at a disadvantage compared to the local producer who can fill local orders more quickly.

South America

South American countries vary from fairly open trading environments to fully closed ones, depending on domestic economy performance and balance of payments problems. The main difficulty here is to establish long-term trading arrangements. In general, South American countries will not import high-value-added products unless there is (a) a need and (b) no viable domestic producer. Some specific examples follow.

Brazil

In order to export nickel to Brazil, an import licence has to be obtained from the state organization CACEX. The approval for such a licence takes a period of 45-60 days. Pending approval, the exporter is obliged to hold this material for possible shipment. Resources and revenues are tied up, with no assurance of sale. Further, orders can be cancelled if domestic producers find that they can supply the nickel during this interim period.

Brazil and Argentina

Both Argentina and Brazil insist that imports by their state companies or partly state-owned companies arrive on domestic flagships. This method of shipment is more costly and often leads to greater delays in payment because of the infrequent sailing dates of these vessels.

Duties (in percentage terms) on zinc exports going to South America are as follows:

Brazil	45	(on drawbacks, 0 percent)
Venezuela	15	*ad valorem* (on obtaining an import licence, the duty falls to 5 percent)
Argentina	38	*ad valorem*

The drawback system allows importation of zinc to produce a product which is then exported. The protected country reaps the value added. This is an example of a extremely high effective rate of protection on domestic processes and would be an example of primary resources shifting towards the domestic producers. Such an arrangement constitutes a large subsidy to the domestic producer, since the value-added production is shifted from the foreign to the domestic supplier.

Other Countries

Egypt

Egypt requires that companies wishing to sell there put up a bid bond (approximately 10 percent of contract value), plus a performance bond (which the government keeps if they feel that the foreign company has failed to conform to the contract). If a company puts forward a bid and does not win it, the bid bond is foregone.

Iran

In Iran, companies wishing to sell there are asked to give 360 days' credit at a special interest rate.

Pakistan

Pakistan requires companies to obtain import licences.

Egypt, Israel and Tunisia have additional restraints. A domestic importer in one of these countries has to earn export credits to pay for imports. These types of restrictions are driven by extremely large balance of payment problems which these countries face at the present time.

The focus of this part of the discussion has been on nickel and zinc exports. Other metallic commodities face a different array of trade barriers, depending on the conditions placed by specific importing countries. However, these examples for nickel show clearly the difficulties faced by Canadian processors as they attempt to penetrate world markets in higher-value-added products. Such foreign restrictions run counter to the goals of the Ontario government's policy as set out in Section 104.

International Trade Agreements

Canadian metal processors, as outlined in the previous section, face a difficult set of problems in gaining larger market shares for their products in overseas markets.

It is important for producers in this country that negotiations proceed on eliminating these tariff and non-tariff barriers. The most important trade agreement has been the Free Trade Agreement (FTA) with the U.S. which came into effect 1 January 1989. This, hopefully, will serve as a model in extending, through multilateral GATT negotiations, trade agreements of a similar kind.

The Canada/U.S. Free Trade Agreement

The primary objective of the Canadian minerals industry in the negotiations for a free trade agreement with the U.S. was more secure and liberal access to US markets.[15] In particular, it was hoped that the agreement would

- eliminate tariff and non-tariff barriers in cross-border trade;
- provide for a constructive dispute-settlement mechanism;
- provide for a phase-in period;
- make provisions to bring legislations in line with each other.

The main beneficiaries of the FTA with the U.S. are Canadian producers of processed and semi-fabricated materials, since ores and concentrates generally entered duty-free. This was particularly the case for Ontario producers of these products since greater value-added production was an established element due at least partly to the encouragement given these producers under Section 104. Any move in the United States to increase effective tariff protection on processed and fabricated products would substantially affect returns to these producers. Such a move was clearly "in the air" in the early 1980s as US producers of these products, faced with depressed domestic markets following the recession of 1981/82, sought more protection for their industries.

Furthermore, as we now observe, Canadian producers already faced high effective tariff rates in offshore markets in Europe and Asia. If the world were to divide itself into large trading blocs, exclusion from the US market, in the absence of a FTA, would force a reallocation of primary resources (labour and capital) towards lower-value-added production. The Canadian industry would then be forced into competition with other raw material producers, many of whom enjoyed high levels of subsidy.

In other words, failure to get the effective tariff rates on processed and semifabricated products reduced under an FTA would push Canadian producers away from the sector in which they enjoyed a comparative advantage. Ontario producers, in particular, had gained such an advantage for the following reasons. First, the processors had an early start due to Section 104 which after World War I induced higher-value-added production prior to export. The contribution of "learning by doing" in gaining an advantage should not be underestimated. Adapting the best-practice techniques takes time and Ontario producers have excelled to the point where they now export such knowledge. Second, cheap energy resources, especially electricity, have provided these producers with an advantage over their US, and possibly foreign, counterparts.

Furthermore, destruction of the higher-value-added component of the Ontario minerals and metals industry would undermine the competitive position of secondary manufacturing operations which are intensive users of such products in their own production process. The latter group then might well be forced to purchase such products elsewhere at potentially higher CIF costs.

Higher effective tariff rates in the United States would have extinguished this net advantage and so undermined much of the previous northern development strategy, designed to enhance employment opportunities for residents of the region. Section 104 was used to implement this strategy, by generating forward linkages to processors and semifabricators. With its comparative advantage well established, the Ontario mineral industry was strongly in

[15] David Anderson, "Implications of the Canada-U.S.A. Free Trade Agreement for the Canadian Minerals Industry", *Ibid*, p. 122.

favour of the FTA both for its immediate gains (access at lower effective rates to the U.S.) and for what such an agreement might do towards fostering other similar bilateral or multilateral trade agreements.

GATT

In order to place the General Agreement on Tariffs and Trade discussion in its proper perspective, a brief overview of the Agreement follows.

Formation

The GATT (General Agreement on Tariffs and Trade) Treaty was formed in 1947 with 23 nations as initial signatories. In 1988 there were 95 contracting parties. Canada was a charter member of the Agreement.

Objective

GATT was formed in response to the wave of protectionism that swept the world during the Great Depression of the 1930s. The fundamental objectives of GATT are

- to provide some kind of orderly framework for the conduct of trading relations;
- to provide a system of rules and codes of conduct which would make it difficult for unilateral action by any nation to raise tariffs;
- to provide a framework for the progressive elimination of trade barriers.

MFN Principle (Article 1 of GATT)

The Most Favoured Nation (MFN) Principle is undoubtedly the keystone in the agreement. According to this principle, if countries A and B agree on a bilateral reduction in tariffs in a given line of goods, this tariff concession should immediately be extended to all other contracting parties on an MFN basis; i.e. all parties benefit to the same extent as the most favoured nation (MFN).

"Rounds" of Trade Liberalization

Periodic rounds of trade liberalization are held and are aimed directly at fulfilling the third objective, namely the progressive elimination of trade barriers.

The series of "Rounds" to date have been

- the Pre-Kennedy Rounds (1947-61);
- the Kennedy Round (1964-67);
- the Tokyo Round (1973-79);
- the Uruguay Round, which began in 1986 and is currently underway. Meetings held in Montreal in early December 1988 were the mid-point of this most recent Round.

Previous rounds have focused on the elimination of tariff and non-tariff barriers (NTBs). The Uruguay Round has focused on three areas: agriculture, services, and intellectual property.

GATT and the Minerals Sector

Pre-Uruguay Rounds

In the pre-Uruguay Rounds, attention focused on tariff reduction in manufactured goods as well as some natural resources. Average tariff levels for raw materials are substantially less than tariffs imposed on finished and semi-finished manufactures. In the post-Tokyo Round, the average tariff on raw materials was 0.4 vs. 4.2 percent on semi-finished and 6.9 percent on finished manufactures.

Uruguay Round

The Uruguay Round, as mentioned above, will focus on agriculture, services, and intellectual property rights. It is not expected that tariffs dealing with the mineral sector will be a topic of discussion. Whatever changes are made – and this depends on

whether negotiations proceed on general tariff structures – will affect the higher-valued products of the mineral industry as well as those segments of the industry that market mining consulting services abroad. The final outcome will not be known until sometime after the Montreal meetings – possibly closer to the end of this Round.

Before proceeding, it is worth reiterating the value of reducing tariff levels. Economic theory suggests that the elimination of tariff and non-tariff barriers will increase welfare, i.e. the real standards of living. This can be seen by reviewing Figure 15. The imposition of a tariff, even in this simple nominal tariff example, has the following effects:

- the level of consumption of the good is reduced;
- prices to consumers are raised;
- factors of production are drawn towards the production of goods that are produced relatively less efficiently than in the source country of these imports; i.e. if these factors of production had remained in areas of higher productivity, the standard of living in the tariff-imposing country would have been higher.

It is possible, however, by unilateral action, for a country to improve its relative economic well-being, at the expense of other countries, by imposing an import duty. An important goal of GATT is to make such unilateral action more difficult and so to create an environment in which mutual trust can be fostered.

The Canadian mining industry and processors are in agreement, regarding the value of GATT, that multilateral negotiations should build upon a completed U.S. Free Trade Agreement. As one can see from the above discussion such a position is a logical extension of the FTA with the United States. It is imperative to the industries that the high *effective* rates of protection now invoked against processed and semifabricated minerals and metals produced in this country be reduced, the ultimate objective being their complete elimination, as will occur under the Canada/U.S. FTA.

Regional Development

A primary goal of the government in Ontario is to foster regional development in the North. One can argue that this goal has been central to all provincial governments in this century and that the imposition of Section 104 and of incentives under the Mining Tax Act is objective evidence of this commitment.

Recent moves towards free trade with the U.S. under the FTA have clear long-term benefits. However, as in all such major changes, uncertainties are present. Clearly, given the comparative advantage of the Ontario processor and semifabricated producers, unfettered access (lower effective tariffs) presents a great opportunity to northern development, i.e. greater employment, high incomes and a technologically more sophisticated production process. The hypothesis is that establishment of Section 104 at the beginning of the century produced the incentives to create higher-value-added production and the fruits of this foresight are about to be reaped.

There are problems, however, in the FTA which will remove subsidies on production for Canadian and US producers alike, although these elements are general and not targeted at the mineral sector. The Ontario mining sector, as part of general government policy, has benefited indirectly from a wide range of regional development initiatives in areas such as road construction, tax concessions, and attractive utility rates. The industry would be vulnerable if such initiatives were successfully challenged, despite the fact that they are exempted under FTA, since without them a number of marginal deposits would cease to be economic and would not be developed. This would hurt northern regional development, since the linkages (backward and forward) that follow from the creation of these production nodes would be lost, and the induced benefits would disappear.

In addition to these spread effects, a (hypothetical) successful challenge to regional development initiatives might increase the cost of production in Canada and so lower its competitive position vis-à-vis the United States. This seems unlikely, however, since the Canadian processing and semifabricating

industry is highly efficient at present and operates from a feedstock that is delivered by an efficient and experienced mining sector – a sector, it should be recalled, that has just gone through a major period of investment, bringing it to the forefront of best-practice technology in the industry. Nevertheless, caution is warranted.

7. Summary of Findings and Recommendations

Since the early decades of this century, successive governments have been committed to the economic development of the northern regions of the Province of Ontario. In line with this broad objective, and after some failed earlier attempts, the government of the day introduced in 1917 what is now Section 104 of the Mining Act of Ontario. This section required companies holding leases on mining lands to refine in Canada ores destined for export. The purpose was to increase the value-added component of mineral commodities sold, by encouraging development of smelting and refining activity within the province.

This study has examined the results of this initiative. In addition, the authors were asked as part of this study to investigate the impact of trade negotiations on the mining sector. A brief summary of the findings is as follows:

- Section 104 had, in the decade after its introduction, a *positive* impact on the amount of domestic processing activity undertaken by the industry in the province, helping it to grow out of its infant industry stage. Although theoretically to be expected, negative impacts on levels of mine production were probably insignificant.

- The justification for introducing Section 104 is quite simple. If the government was to secure a larger share of the gains from this nonrenewable resource, it had to ensure that part of the processing be done within provincial boundaries. While the Act specified processing in Canada, other factors such as transportation costs, tax incentives, and energy prices could ensure that some processing would take place in Ontario. Otherwise, these surpluses would be exported, along with the raw materials.

  An added benefit in this policy was the creation of a new industry in Ontario – smelting and refining. This industry grew vigorously over time, became technologically sophisticated, and established itself as a major competitor on world markets. In the course of this development, jobs were created, incomes generated, and investment undertaken. These were the direct effects. The indirect effects via multipliers were also important in the development of the North and the Province as a whole.

- The increases in domestic processing, whether induced primarily by Section 104 or by economic forces, have apparently occurred in a series of traverses. These traverses were first observed when the long-term trend in the ratio of unit prices (total value of production divided by quantity) to world metal prices was studied. Periodic sharp increases in this ratio indicate that the composition of total production has shifted towards higher levels of value added. The latter is a measure of greater domestic processing.

  These discontinuities have been associated both with technological change (reduced energy costs in the early part of the century) and with market forces, especially in times of intense competition from non-Canadian suppliers. Section 104, therefore, has acted as a permissive rather than a proactive institutional arrangement, inducing producers to seek cost-effective methods of increasing the value-added component of exported metals. An indication of the extent to which smelting and refining growth was due to economic forces after Ontario's economy had matured has been the increase and the health of industries processing raw materials originating outside of Ontario, such as Hamilton's steel industry.

- An individual commodity review over a long period shows an overall increase in the percentage of Ontario mine output that is processed in Canada, although this varies between metals.

- From 1964 to 1986, value added in smelting and refining grew at an annual compound rate of 7.7 percent, while mining value added grew at 6.6 percent per year. However, value added per employee man-year for mining still exceeds that for smelting and refining by 63 percent. ("Value added" measures the amount of capital and labour used in production.)

- The implication of this high rate of growth in value added is that the domestic processing requirement has effectively contributed to employment and income generation in Northern Ontario (see Tables 4 to 7). Application of simple multiplier effects to the basic wage and purchase bills generated by the smelting and refining sector indicated that this sector alone accounts for close to 4 percent of the total income flow in the North. If this type of calculation were applied to specific urban areas such as Sudbury and Timmins, the impact would be even greater.

- The growth in value added implies expanded investment levels and hence the adoption of new technology. This has strengthened the competitive position of the industry. In addition, the industry has become a supplier of new technology and mining services to other countries.

- The authors would recommend a closer examination of the development of indigenous technology in the mining industry. The public awareness of the extent to which new ideas are generated domestically (versus being imported) needs to be bolstered. The linkages to other sectors such as manufacturing and service-related activities can be very important, since they generate additional employment and income for the North and for the Province.

- Company Survey on Domestic Processing

  The authors sent a questionnaire to Ontario nonferrous metal producers (Appendix C) asking them about the extent of domestic processing activity and how this had changed over time.

  Examination of the returns suggests the following:

- The most important change in the industry between the 1970s and 1980s was the shift from a production-driven (supply) to a market-driven (demand) focus in corporate planning.

- As a result of this shift (driven by the uncertain markets of the late 1970s and early 1980s), the nonferrous metal industry is beginning to transform its production process to meet more clearly the needs of its customers. This is critical for our investigation of the extent of domestic processing since it implies a much greater emphasis on more sophisticated products and hence a larger share of exports with a higher value-added component. Such a trend is clearly the wave of the future for this industry.

- The main implication of this shift is that the industry will be required to adapt its production processes to meet the changing needs of its customers. This will involve greater sophistication in both marketing and production than has been the case in the past.

- This dramatic change is largely limited to nickel and copper producers. Our survey of uranium producers indicates that few changes have occurred in this industry.

- Impact of the FTA and GATT Negotiations

  The authors have drawn information for this section from a number of areas. In the main, however, they have sought the view of the industry both through questionnaires and through meetings with officials of various mining companies. The main findings were as follows:

- It is clear from discussions with the industry that attempts by producers to increase the proportion of domestic processing (i.e. to enhance the value-added component of nonferrous exports) are being constrained by the structure of tariffs imposed by importing countries. This problem is particularly severe for exports to Japan and to other countries, including China, India, and East Bloc and South American countries.

The tariff structure of these importing countries is such as to impose higher effective rates of duty on more processed nonferrous metals. Such measures are the mirror images of Ontario's Section 104 and serve, in these countries, similar policy objectives. Even with the high level of efficiency of Canadian producers, the levels of protection are too high to permit them profitable access to the markets. A reduction in the level of tariffs on higher-valued products would have a positive effect on the extent of domestic processing in Ontario and therefore reinforce the benefits sought under Section 104 of the Mining Act.

- This last point is particularly relevant in light of the discussion in the previous section on new market conditions facing the industry. As firms shift towards a more demand-driven market, production will shift towards more sophisticated (higher-value-added) products. Tariff levels that discriminate against the import of such products will make it difficult for the industry to adjust production and so increase the amount of domestic processing.

Conclusion

Overall, the introduction of Section 104 of the Mining Act in 1917 had a positive impact, and shows a positive correlation with the early rapid growth of domestic processing in the Province of Ontario. It has therefore helped to set the base for future expansion.

Recommendations

In light of these findings, the authors would recommend that the Province of Ontario undertake the following initiatives:

- *The Province of Ontario should petition the federal government to include, as part of its GATT negotiations, specific requests for the reduction of tariffs on higher-value-added mineral and metal imports among such countries as Japan, Brazil, etc.* Failure for our metal processors to gain access to these markets will force production down the value-added scale (towards raw material exports), a trend counter to that fostered by the provincial government since the turn of the century. Further, such a restructuring would place the industry at greater risk since it would be competing with countries selling the same products but doing so in a highly subsidized environment.

- *In line with this thrust, the provincial government might consider joining with industries to examine the precise extent of effective protection accorded domestic processors, especially in countries with potentially large markets for Canadian products.* Precise estimates of effective protection levels are clearly essential if negotiations are to be fruitful.

Appendix A

A list of smelting plants and refineries operating in Canada in 1988-89 is as follows:

Copper Smelters

Falconbridge Limited – Kidd Creek Division, Timmins, Ontario
Hudson Bay Mining and Smelting Company Ltd. – Flin Flon, Manitoba
Noranda Incorporated
(1) Gaspe Division, Murdochville, Québec
(2) Noranda, Québec

Copper-Nickel Smelter

Falconbridge Limited – Falconbridge, Ontario.
Inco Limited
(1) Copper Cliff, Ontario
(2) Thompson, Manitoba

Lead Smelters

Brunswick Mining and Smelting Corp. Ltd. – Belledune, N.B.
Cominco Limited – Trail, B.C.

Magnesium-Calcium-Strontium Smelters

Chromasco, a division of Timminco Limited
(1) Haley, Ontario
(2) Beauharnois, Québec

Molybdenum Roaster

Placer Dome Inc. – Endako Mines Division, Endako, B.C.

Titanium Smelter

QIT-Fer et Titane Incorporated – Sorel, Québec

Copper Refineries

Inco Limited – Sudbury, Ontario
Falconbridge Limited – Kidd Creek Division, Timmins, Ontario
Noranda Incorporated – CCR Division, Montréal, Québec

Lead Refineries

Brunswick Mining and Smelting Corp. Ltd. – Belledune, N.B.
Cominco Limited – Trail, B.C.

Gold Refineries

Degussa Canada Limited – Burlington, Ontario
Royal Canadian Mint – Ottawa, Ontario
Johnson Matthey Limited – Brampton, Ontario

Nickel Refineries

Inco Limited
(1) Copper Cliff, Ontario
(2) Port Colborne, Ontario
(3) Thompson, Manitoba
Sherritt Gordon Mines – Fort Saskatchewan, Alberta

Silver Refineries

Agnico Eagle Mines Limited – Cobalt, Ontario (closed)
Cominco Limited – Trail, B.C.
Degussa Canada Limited – Burlington, Ontario
Johnson Matthey Limited – Brampton, Ontario
Noranda Incorporated – Montréal, Québec
Royal Canadian Mint – Ottawa, Ontario
Inco Ontario Division – Port Colborne

Uranium Refineries

Eldorado Resources Limited – Port Hope, Ontario

Vanadium Refinery

Renzy Mines Limited/Agra Industries Limited – Fort McMurray, Alberta

Zinc Refineries

Canadian Electrolytic Zinc Limited (Noranda) – Valleyfield, Québec
Cominco Limited – Trail, B.C.
Falconbridge Limited – Kidd Creek Division, Timmins, Ontario
Hudson Bay Mining and Smelting Company Ltd. – Flin Flon, Manitoba

Appendix B

Table 1. Consumer price index for Canada, 1900-1985 (1981 = 100)

1961	31.6	1974	52.8
1962	32.0	1975	58.5
1963	32.6	1976	62.9
1964	33.2	1977	67.9
1965	34.0	1978	73.9
1966	35.2	1979	80.7
1967	36.5	1980	88.9
1968	38.0	1981	100.0
1969	39.7	1982	110.8
1970	41.0	1983	117.2
1971	42.2	1984	122.3
1972	44.2	1985	127.2
1973	47.6	1986	132.4
		1987	138.2

Source: Consumer Prices & Price Indices, Statistics Canada, Cat. #62-010

Table 2. Metal price index - Canada, 1961-1985 (1975 = 100)

1961	37.96	1974	114.46
1962	41.01	1975	100.00
1963	42.06	1976	100.11
1964	51.07	1977	107.85
1965	56.81	1978	121.98
1966	59.57	1979	176.64
1967	54.81	1980	205.92
1968	57.97	1981	181.62
1969	62.80	1982	162.77
1970	64.69	1983	170.50
1971	58.12	1984	169.09
1972	60.84	1985	169.23
1973	92.01		

Source: Energy, Mines and Resources, Ottawa, Canada

Table 3. Ratio of unit price to LME metal price, 1900-85

Year	Nickel	Copper	Lead	Zinc	Silver	Gold	Average for 6 Metals
1900	.21	.29	-	-	.98	.76	.56
1901	.28	.40	-	-	.94	.84	.62
1902	.41	.64	-	-	1.15	1.24	.86
1903	.45	.36	.94	-	1.05	1.50	.86
1904	.40	.52	.81	-	.95	.77	.86
1905	.44	.48	.68	-	.92	.98	.70
1906	.44	.40	.75	-	1.02	1.06	.73
1907	.24	.36	-	-	.94	.81	.59
1908	.22	.53	-	-	.89	.97	.65
1909	.27	.54	-	-	.94	.80	.64
1910	.27	.55	-	-	.95	.82	.65
1911	.27	.56	-	-	.96	1.04	.71
1912	.26	.43	.43	-	.95	1.01	.62
1913	.26	.46	-	-	.93	.99	.66
1914	.27	.54	-	-	.93	1.00	.69
1915	.60	.57	-	-	.99	1.00	.79
1916	.60	.65	1.30	-	.97	1.00	.90
1917	.60	.64	1.12	-	1.02	1.00	.88
1918	.74	.62	1.20	-	1.03	1.00	.92
1919	.68	.78	1.10	-	1.02	1.00	.92
1920	.63	.75	1.00	-	.77	1.12	.85
1921	.58	.83	1.17	-	1.07	1.09	.95
1922	.60	.76	1.05	-	1.06	1.01	.90
1923	.50	.84	.91	-	.99	1.01	.85
1924	.61	.83	.94	-	1.01	1.01	.88
1925	.66	.84	.92	.97	1.00	1.00	.90
1926	.61	.83	.93	-	.98	1.00	.87
1927	.66	.83	.98	-	1.01	1.00	.90
1928	.61	.87	.93	.80	1.00	1.00	.87
1929	.68	.90	.90	.79	.97	1.01	.88
1930	.66	.84	.96	.73	1.00	1.00	.87
1931	.66	.96	1.00	-	1.07	1.04	.95
1932	.68	1.00	.73	-	1.09	1.13	.93
1933	.69	.97	.86	-	1.07	1.36	.99
1934	.71	.85	1.18	-	.98	1.03	.95
1935	.73	.87	1.07	-	1.00	1.00	.93
1936	.74	.97	1.25	-	.99	1.00	.99

Table 3. Ratio of unit price to LME metal price, 1900-85 (continued)

Year	Nickel	Copper	Lead	Zinc	Silver	Gold	Average for 6 Metals
1937	.76	.97	1.11	.73	.99	1.00	.93
1938	.73	.97	.96	-	1.01	1.01	.94
1939	.64	.90	.51	-	1.03	1.04	.82
1940	.70	.88	.67	-	1.05	1.10	.88
1941	.69	.84	.59	.44	1.08	1.10	.79
1942	.78	.83	.52	.39	1.06	1.10	.78
1943	.79	.97	.58	.46	.96	1.10	.81
1944	.80	1.00	.69	.49	.94	1.10	.84
1945	.80	1.04	.76	.73	.87	1.10	.88
1946	.64	.80	.78	.76	.98	1.00	.83
1947	.85	.93	.94	-	.99	1.00	.94
1948	.91	.99	1.00	-	1.04	1.00	.99
1949	.94	.99	-	-	1.01	1.00	.99
1950	.93	.99	-	-	1.03	1.00	.99
1951	.96	.99	-	-	1.00	1.00	.99
1952	.98	.91	1.00	1.11	1.00	1.02	1.00
1953	.95	.98	.98	1.14	1.00	1.00	1.01
1954	.95	.99	.97	1.15	1.00	1.00	1.01
1955	.95	.95	.95	1.13	1.00	1.00	1.00
1956	.97	1.03	.98	1.12	1.00	1.00	1.02
1957	.97	1.10	.99	1.11	1.00	1.00	1.03
1958	.97	1.07	.97	1.09	1.01	1.00	1.02
1959	.97	1.06	.91	1.11	1.00	1.00	1.01
1960	.96	1.03	.92	1.06	1.00	1.00	1.00
1961	.96	1.02	.93	1.08	1.01	1.00	1.00
1962	.96	1.01	.96	.97	1.01	1.00	.99
1963	.97	1.02	.92	.99	1.00	1.00	.98
1964	.97	.99	.92	.97	1.00	1.00	.98
1965	.97	.97	.90	.97	1.00	1.00	.97
1966	.99	.84	.92	.97	1.00	1.00	.95
1967	.98	.93	.93	.97	1.04	1.00	.98
1968	.97	.88	.94	.97	1.00	.88	.94
1969	.99	.77	.95	.97	1.00	.85	.92
1970	1.01	.89	.97	1.00	1.00	.97	.97
1971	1.09	1.09	.97	1.03	.88	.86	.99
1972	1.03	1.10	1.04	1.08	1.00	1.00	1.04
1973	.98	.81	.99	1.17	.99	1.00	.99

Table 3. Ratio of unit price to LME metal price, 1900-85 (continued)

Year	Nickel	Copper	Lead	Zinc	Silver	Gold	Average for 6 Metals
1974	.83	.87	.94	.99	1.01	1.00	.94
1975	1.08	1.18	.93	.95	1.00	1.00	1.02
1976	1.06	1.14	.99	1.03	1.00	1.00	1.04
1977	.92	1.15	.96	.97	1.00	1.00	1.00
1978	1.07	1.10	.96	.98	1.00	1.00	1.02
1979	.96	1.06	.97	1.00	1.00	1.00	1.00
1980	1.03	1.05	.94	.99	.94	.73	.95
1981	1.08	1.16	1.23	.99	1.03	.86	1.06
1982	1.19	1.14	1.00	.98	1.13	1.00	1.07
1983	1.13	1.13	.77	.94	1.09	1.03	1.02
1984	1.13	1.17	1.02	1.02	.98	1.05	1.06
1985	1.14	1.17	.94	1.00	1.09	1.08	1.07

Source: Calculated using LME prices, and "1988 Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, Mineral Development and Lands Branch.

Table 4. Value of exports and imports to Canada of nickel and ratio of exports to imports Selected years, 1920 to 1960

Year	Exports	Imports	Ratio Exports/Imports
1920	9,039	2,277	3.97
1925	10,173	3,425	2.97
1930	25,035	3,792	6.60
1935	28,423	1,180	24.09
1940	61,163	1,832	33.39
1945	54,778	1,481	36.99
1950	105,300	6,880	15.31
1955	215,169	5,662	38.00
1960	258,331	5,708	45.26

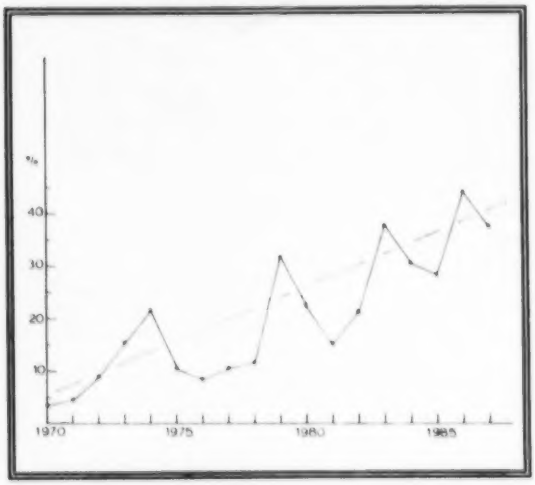
Source: *Canada Year Book*, by year, External Trade Sector.

Table 5. Shares of volumes and values of Ontario nickel products, 1970-1987

1	2	3	4	5
1970	121.9	125.8	126.2	3.53
1971	132.0	138.0	138.0	4.55
1972	119.1	125.6	129.8	8.98
1973	110.4	121.9	127.3	15.31
1974	90.3	96.2	109.5	21.26
1975	126.1	134.6	139.2	10.39
1976	115.2	120.8	124.8	8.24
1977	125.9	130.8	138.9	10.33
1978	125.6	128.2	140.3	11.70
1979	97.9	106.0	129.1	31.87
1980	109.9	124.5	134.5	22.38
1981	128.6	146.8	147.9	15.01
1982	135.2	154.9	163.6	21.01
1983	116.9	127.4	161.0	37.72
1984	120.1	135.0	156.7	30.47
1985	118.6	124.4	151.9	28.08
1986	118.4	123.7	170.5	44.00
1987	106.8	110.3	145.0	37.77

Source: Data prepared by Dr. Gerry Anders, Chief Research Analyst, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines (1988).
Col. 1: Year
Col. 2: Value per pound of lowest-valued third of production as percent of deemed matte value
Col. 3: Value per pound of middle-valued third of production as percent of deemed matte value
Col. 4: Value per pound of highest-valued third of production as percent of deemed matte value
Col. 5: Percentage difference between columns 2 and 4
Note: To illustrate changes in product mix from 1970 to 1987, all Ontario nickel products other than matte were divided into three groups of equal volume in ascending order of value added. The table reflects, particularly in column 5, the extent to which refined production has increasingly focussed on maximizing value added.

Figure 18. Nickel – difference between average unit prices, lowest- and highest-valued third of production, 1970-1987



Appendix C

Questionnaire (copies of originals)

SECTION A

The objective of this study is to examine new product development in the Ontario metal mining industry over the last 15 years. We would like to develop a record of major changes in product mixes as far back as we can, although we realize that this may only be possible in general terms. As such we would appreciate answers to the following questions. Forms have been provided to assist you with documenting this information.

SECTION A - Questions

1. What products or major product groups did your firm produce in 1988, 1985, 1980, 1975, and 1970? Please be as specific as possible (col. 1).

2. What was the volume and value of sales of each of the products listed in Question #1 (col. 2 and col. 3)?

3. What country (or countries) provides the major market for each of your projects (col. 4)?

4. Do (did) you produce the products outline in Question #1 (a) in Ontario; (b) elsewhere in Canada (specify); (c) outside Canada (specify)? Please provide the location of production for each product or product group (col. 5).

5. What were the reasons for the introduction of new products set out in Question #1 (a) new market opportunities or (b) new technological advances in the metal mining industry (col. 6)?

6. Did the introducion of these new products require you to invest in (a) new plants or, (b) alterations to existing facilities (col. 7)?

SECTION A QUESTIONNAIRE

Year

Company

Operating Unit

Product or Product Group	Sales		Market	Place of Production	Reason Introduction of New products
Name/Type	Volume	Value	Countries		
(1)	(2)	(3)	(4)	(5)	(6)

SECTION B

The Ministry of Industry, Trade and Technology has asked us to seek information which may assist them in establishing a "metals industry position" in federal-provincial discussions concerning the Uruguay GATT round of negotiation. The questions which have been suggested by MITT are the following. Please feel free to modify these to fit your company-specific situation, if necessary.

SECTION B - Questions

QUESTIONS ON TARIFFS AND NTB's
URUGUAY MTN ROUND

1. In which countries are the manufacturing industries you represent having the most difficulty gaining entry because of trade barriers?

2. What are the principal trade barriers in these countries?

3. Can you identify more specifically, for particular countries and industries, which tariffs or NTB's pose the greatest problems?

4. a) Which tariffs applied by Canada against countries other than the U.S. would your industry members consider it necessary to retain?
   b) To what extent might tariff reductions be acceptable?

5. a) Which non-tariff measures applied by Canada or Ontario against countries other than the U.S. would your industry members wish to have retained?
   b) To what extent would reductions in NTB's be acceptable?

6. What Canadian Tarriffs/NTB's would your industry members like to see removed or reduced?

7. This MTN round seeks to include trade in services in a significant way for the first time. In what ways would this impact on the export and import of services by your membership?

8. Have any of your industry members expressed concern or interest in regard to specific MTN negotiating issues such as, subsidies and countervailing measures, safeguards, dispute settlement, trade related investment measures, or intellectual property rights?

9. Do you have any concerns with respect to possible effect of the multilateral trade negotiations on:

   a) the overall status of the Canada-U.S. FTA?
   b) any specific sections of, or issues raised in, the FTA?

The Authors

Alan G. Green received his Honours B.A. in economics from Queen's University at Kingston and his doctorate from Harvard University. He has been a member of the faculty of the Economics Department at Queen's since 1963. While conducting research in a broad range of topics in economics and economic history, he has been a visiting research fellow at Yale, Harvard and the Australian National University, as well as the University of York, England.

Dr. Green has published widely in economics. During the past few years, he has had a particular interest in the mineral industry and has written a number of books and articles on the industry in Canada and Australia. Together with Ann Green, he has been awarded several contracts by the Ontario Ministry of Northern Development and Mines (formerly the Ministry of Natural Resources) for research into various aspects of the Ontario mining and mineral processing industry.

M. Ann Green has an honours degree in economics and mathematics (Queen's University) and has undertaken postgraduate work in applied economics. Her main area of research has been on the mining industry, especially on studies dealing with the efficiency of this industry. She is co-author, with Alan Green, of a number of publications on the Canadian and Australian mining industries.

Gerhard Anders has a masters degree in mining engineering (1955 Clausthal, Germany) and a Ph.D. in economics (Texas A&M, 1972). He has worked in the mining industry in Europe and Canada, in government, and has taught economics in the U.S. and in Canada and has over 40 publications in engineering and economics. He is now Chief Research Analyst, Mineral Development and Lands Branch, Ontario Ministry of Northern Development and Mines in Sudbury.

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